MAGTROL

TF Series

Torque Flange Sensors



User's Manual

Purchase Record

Please record all model numbers and serial numbers of your Magtrol equipment, along with the general purchase information. The model number and serial number can be found on either a silver identification plate or white label affixed to each unit. Refer to these numbers whenever you communicate with a Magtrol representative about this equipment.

Model Number: _____

Serial Number: _____

Purchase Date: _____

Purchased From: _____

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Second English Edition, revision F – July 2011

MAGTROL

Safety Precautions



WARNING! IN ORDER TO MINIMIZE RISKS, IT IS OF UTMOST IMPORTANCE TO RESPECT THE CURRENT SAFETY STANDARDS WHEN PLANNING, CONFIGURING AND OPERATING THE TORQUE MEASUREMENT DRIVE TRAIN.



CAUTION: OPERATE THE TF SERIES TORQUE FLANGE SENSOR WITH GREAT CAUTION! THE SENSOR MAY BE IRREVERSIBLY DAMAGED IF IMPACTED MECHANICALLY (FALL), CHEMICALLY (ACIDS) OR THERMALLY (HOT AIR, VAPOR).

1. Make sure that all Magtrol electronic products are earth-grounded, to guarantee personal safety and proper operation.
2. Check line voltage before operating electronic equipment.
3. Make sure that all rotating parts are equipped with appropriate safety guards.



Note: Detailed information regarding safety guards can be found in *Section 2.6 – Protective Systems*.

4. Periodically check all connections and attachments.
5. Always wear protective glasses when working close to rotating elements.
6. Never wear a necktie or baggy clothes when standing close to rotating elements.
7. Never stand too close or bend over the rotating drive chain.

QUALIFIED PERSONNEL

Persons in charge of installing and operating the TF Series Torque Flange Sensor must have read and understood this User's Manual, paying extra close attention to all safety-related information.

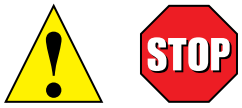
The TF Sensor is a high-precision product integrating the most recent measurement techniques. The sensor can give rise to residual dangers if used and manipulated in a non-compliant way by unqualified personnel.

This sensor must be handled by qualified personnel according to the technical requirements and the above-mentioned safety instructions. This is also true when using torque flange accessories.

RESIDUAL HAZARDS

Sensor performance is only one element in torque measurement. Safety is of equal importance. There are possible residual hazards when operating rotating test equipment and it is the responsibility of the designer, the manufacturer and the user to minimize these hazards.

In addition to general safety precautions, residual hazards are highlighted in this manual by using the following symbols:



Please read the Preface for a more detailed description of each symbol.

PROPER USE

The use of TF Series Torque Flange Sensors is exclusively restricted to torque and rotational speed measuring tasks and directly-related control and regulating tasks. Any further use shall be deemed to be improper.

For safe operation, the TF Sensor and its accessories may only be used according to the data and specifications given in this User's Manual. Safe operation can be guaranteed only when the sensor is correctly transported, stored, installed, mounted and used.

MODIFICATIONS

The TF Torque Flange Sensor and its accessories may not be modified without the express consent of Magtrol. Magtrol is not be liable for any consequential damages resulting from unauthorized modifications.

Revisions to This Manual

The contents of this manual are subject to change without prior notice. Should revisions be necessary, updates to all Magtrol User's Manuals can be found at Magtrol's website at www.magtrol.com/support/manuals.htm.

Please compare the date of this manual with the revision date on the website, and then refer to the manual's Table of Revisions for any changes/updates that have been made since this edition.

REVISION DATE

Second English Edition, revision F – July 2011

TABLE OF REVISIONS

Date	Edition	Change	Section(s)
07/04/11	2nd edition, rev. F	text concerning parasitic forces updated	4.4
11/12/09	2nd edition, rev. E	New information about the cardan shaft was added in section 2.2.4.5. New information about radial forces, axial forces and dynamic limit was added to section 4.4.	2.2.4.5, 4.4
06/18/09	2nd edition, rev. D	Changed values for TF 220	2.2.4.1
03/31/09	2nd edition, rev. C	Added (N/C for 5W conditioner) to pin 7	2.5.3.1
03/27/09	2nd edition, rev. B	0.5 mm distance changed to 1.5 mm distance	2.4.1
06/03/08	2nd edition, rev. A	New design for standard speed sensor	1.2, 2.41

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Preface

PURPOSE OF THIS MANUAL

This manual contains all the information required for the setup, connection and general use of Magtrol's Torque Flange Sensors of TF200 series. Please read this manual in its entirety before operating. Keep the manual in a safe place for quick reference whenever a question should arise.

WHO SHOULD USE THIS MANUAL

This manual is intended for those who install Torque Flange Sensors on a bench test or to use it to determine the couple on a transmission chain. The operator is assumed to have the necessary technical training in mechanical engineering and electronics to enable him to install these Torque Flange Sensors.

MANUAL ORGANIZATION

This section gives an overview of the structure of the manual and the information contained within it. Some information has been deliberately repeated in different sections of the document to minimize cross-referencing and to facilitate understanding through reiteration.

The structure of the manual is as follows:

Chapter 1: INTRODUCTION – Contains the technical data sheets for the Torque Flange Sensors of TF200 series, which describe the units and provide an overview of their possible applications.

Chapter 2: INSTALLATION/CONFIGURATION – Provides the information needed for the setup and connection of the Torque Flange Sensors.

Chapter 3: STARTUP – Give the instructions to start the system and adjust the zero of the measuring chain.

Chapter 4: MEASUREMENT CONSIDERATIONS – Describes the limits of measures.

Chapter 5: OPERATING PRINCIPLES – Contains information on lubrication procedures and provides recommendations for the calibration and checking of the measuring current and voltage.

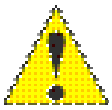
Chapter 6: TROUBLESHOOTING/MAINTENANCE – Give the procedure to follow in case of breakdown of a Torque Flange Sensors TF.

CONVENTIONS USED IN THIS MANUAL

The following symbols and type styles may be used in this manual to highlight certain parts of the text:



Note: This is intended to draw the operator's attention to complementary information or advice relating to the subject being treated. It introduces information enabling the correct and optimal function of the product.



CAUTION: THIS IS USED TO DRAW THE OPERATOR'S ATTENTION TO INFORMATION, DIRECTIVES, PROCEDURES, ETC. WHICH, IF IGNORED, MAY RESULT IN DAMAGE TO THE MATERIAL BEING USED. THE ASSOCIATED TEXT DESCRIBES THE NECESSARY PRECAUTIONS TO TAKE AND THE CONSEQUENCES THAT MAY ARISE IF THESE PRECAUTIONS ARE IGNORED.



WARNING! THIS INTRODUCES DIRECTIVES, PROCEDURES, PRECAUTIONARY MEASURES, ETC. WHICH MUST BE EXECUTED OR FOLLOWED WITH THE UTMOST CARE AND ATTENTION, OTHERWISE THE PERSONAL SAFETY OF THE OPERATOR OR THIRD PARTY MAY BE AT RISK. THE READER MUST ABSOLUTELY TAKE NOTE OF THE ACCOMPANYING TEXT, AN D ACT UPON IT , BEFORE PROCEEDING FURTHER.

1. Introduction

1.1 SYSTEM COMPONENTS

The complete TF Series torque measuring system consists of the following four primary components:

1. Measuring Flange with Signal Amplifier
2. HF Transmitter
3. Conditioner
4. Coaxial Cable (4 m)

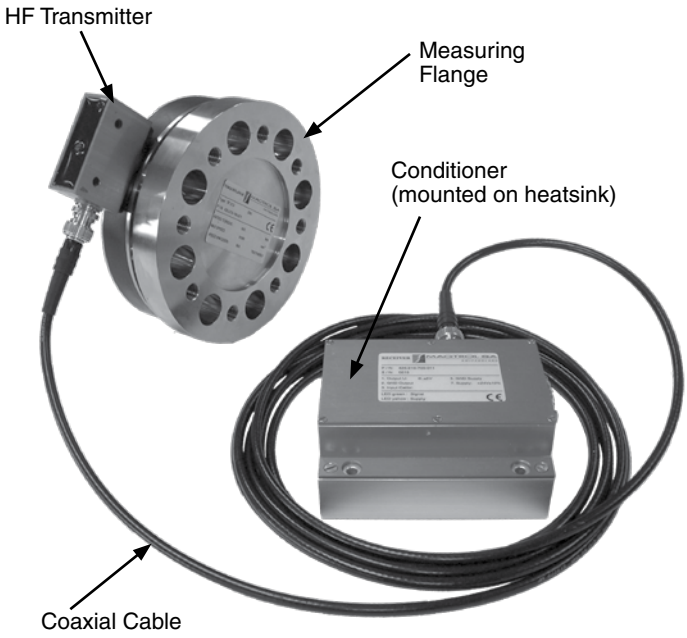


Figure 1–1 TF Series Torque Flange Sensor Kit

System options include the Speed Sensor and Conditioner, and the 3410 Display

1.1.1 MEASURING FLANGE

The measuring flange represents the rotor part of the torque sensor. It is made of steel and contains 4 strain gauges in full-bridge configuration, an amplifier, a low-pass filter and an A/D converter. It is fitted with an electromagnetic track around its circumference which acts as an antenna for sending telemetric transmissions to the HF transmitter and, ultimately, the conditioner.

1.1.2 HF TRANSMITTER

The high-frequency transmitter represents the stator part of the transducer. This transmitter receives the signal from the measuring flange and relays it to the conditioner.

1.1.3 CONDITIONER

The torque conditioner supplies power to the measuring flange, via the HF transmitter, and collects the torque signal measured by the system. To display measured values, the conditioner must be connected to a Magtrol 3410 Torque Display (see *Section 1.1.6 – Signal Processor/Display Unit*) or similar device.

TF Model	Power	Mounting
TF 209 – TF 217	1.5 W	Mounted on heatsink (for heat dissipation)
TF 218 – TF 220	5 W	Mounted inside electronics module

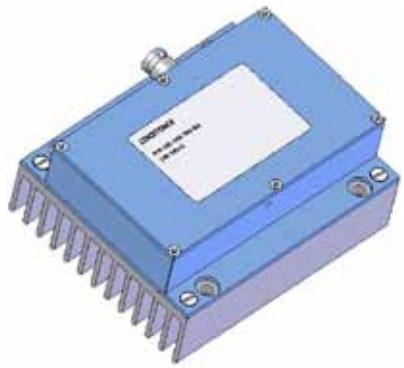


Figure 1–2 Conditioner for TF 209 – TF 217 Torque Flange Sensors

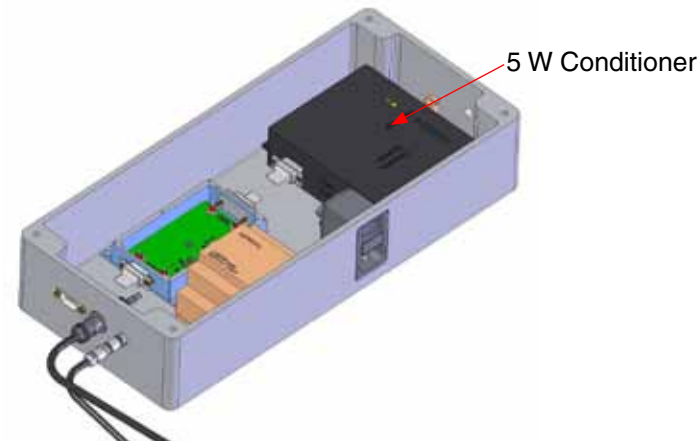


Figure 1–3 Electronics Module for TF 218 – TF 220 Torque Flange Sensors

1.1.4 COAXIAL CABLE

The shielded RG-58 coaxial cable between the HF transmitter and the conditioner has an impedance of 50 Ohms and is 4 meters long (8 m, 12 m, 16 m and 20 m cables are available as an option).

1.1.5 Speed Measurement Option

When ordered with the optional speed measurement capability, the TF Torque Sensor is fitted with a toothed rim with the speed sensor attached to the exterior (as shown in the figure below).

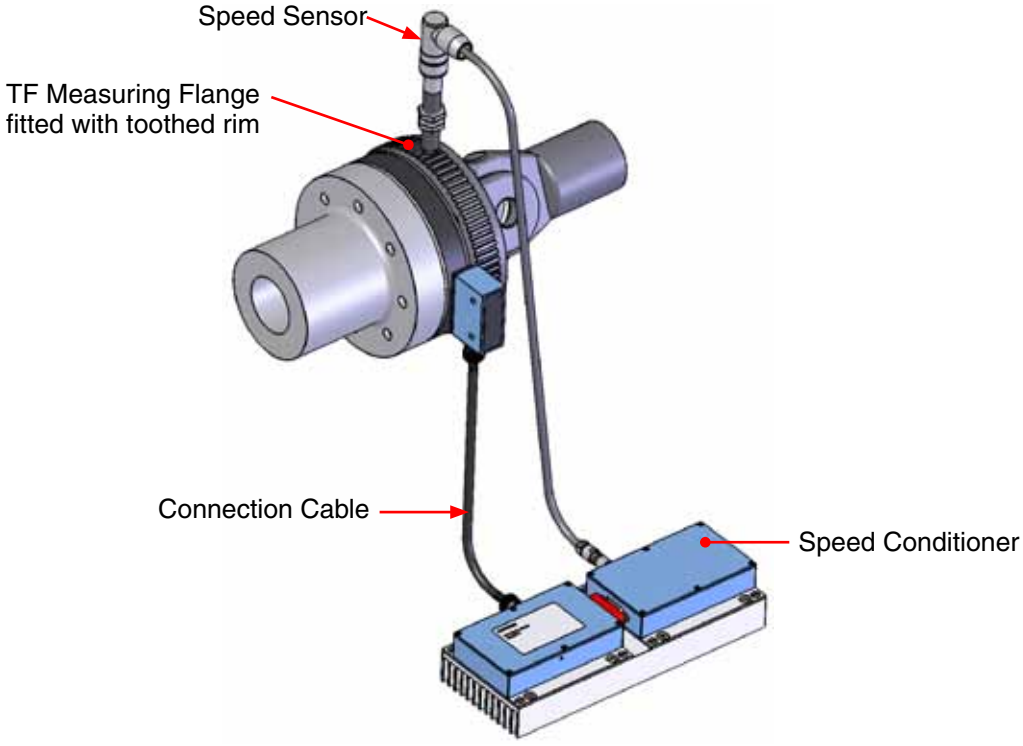


Figure 1–4 Mounted TF Torque Flange Sensor with Speed Measurement Option

1.1.6 Signal Processor/Display Unit

Available as a system option, Magtrol's 3410 Torque Display processes the torque and speed signals from the TF Sensor and displays the measured values and calculated power. For additional data processing, the unit has an RS-232 interface (*cable sold separately*) for connection to a PC and is delivered with Magtrol's Torque 1.0 Software.

Torque 1.0 is a user-friendly Windows® executable program, developed under LabVIEW™, used to automatically collect torque, speed and mechanical power data. The data can be printed, displayed graphically or quickly saved as a Microsoft® Excel spreadsheet.



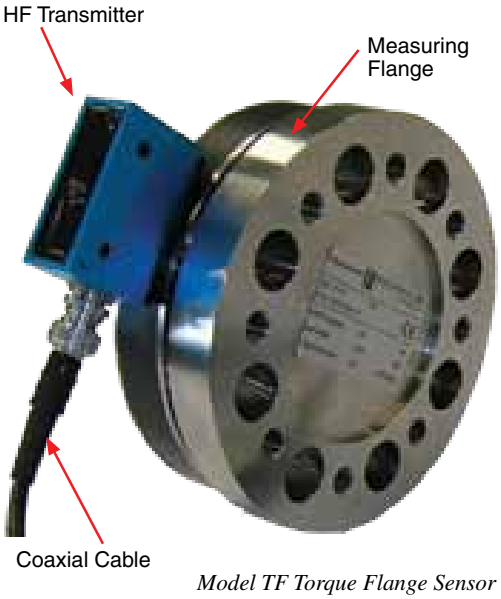
Figure 1–5 Model 3410 Torque Display

1.2 DATA SHEET

TF Series
Torque Flange Sensor

FEATURES

- Complete torque measuring system consisting of:
  - Measuring flange with signal amplifier
  - HF transmitter
  - Conditioner
  - 4 m coaxial cable
- Contactless signal transmission: via telemetry
- Torque range: 50 N·m to 150,000 N·m
- High accuracy: 0.1% to 0.25%
- Overload capacity: up to 200% (limit of adhesion)
- Measuring range: 200%
- Braking torque: 400%
- Compact, easy-to-mount design
- High torsional stiffness
- Bearingless: maintenance and wear-free
- Excellent noise immunity and shock resistance
- Protection class: IP 42 (IP 54 optional)
- 24 V DC standard power supply
- Integrated speed sensor and conditioner (option): for rotational speed measurement
- High temperature capability: up to 125 °C (optional)



Model TF Torque Flange Sensor

DESCRIPTION

With its compact, bearingless, maintenance-free design, the new TF Torque Flange Sensor from Magtrol brings many appealing advantages to torque measurement applications. The TF's high torsional rigidity supports direct mounting on the machine shaft or flange, avoiding the use of couplings on one side. This allows easy integration into a test system, shortens the overall length of the test bench and reduces costs.

Based on strain-gauge technology, the TF Sensor's precise telemetry system enables highly accurate signal transmission. A signal amplifier mounted in the measuring flange amplifies the measuring signal, modulates it to high frequency and transmits it inductively (via the HF transmitter) to the conditioner. In the conditioner, the digitized torque signal is transformed into an analog output signal of ±5 V DC. Rotational speed can be measured and converted to a TTL output signal with the optional speed sensor.

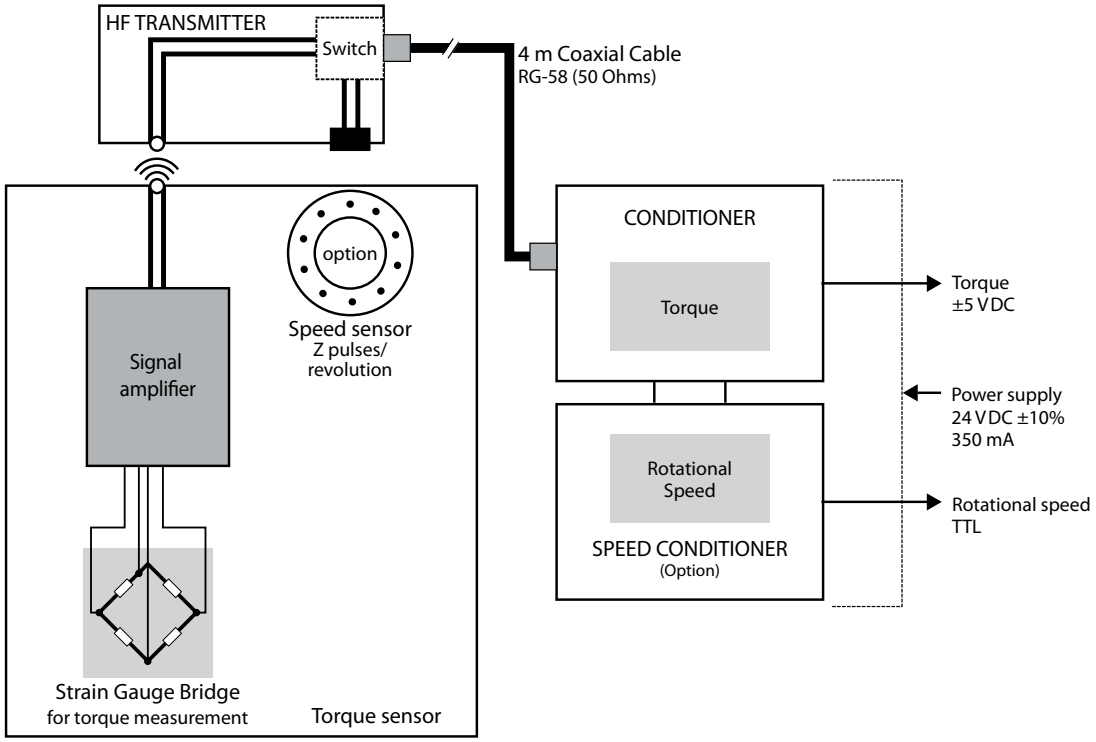
The contactless design of the Torque Flange Sensor permits a gap of up to 5 mm (typically 1 to 3 mm) between the rotor antenna and HF transmitter, which makes the signal acquisition insensitive to any axial or radial misalignment. Another advantage of this torque measurement system is its insusceptibility to signal interference—due to the fact that, unlike other designs, the antenna does not need to be looped around the measuring flange. Additionally, a protective cover can be mounted close to the TF Sensor with no effect on the signal.

APPLICATIONS

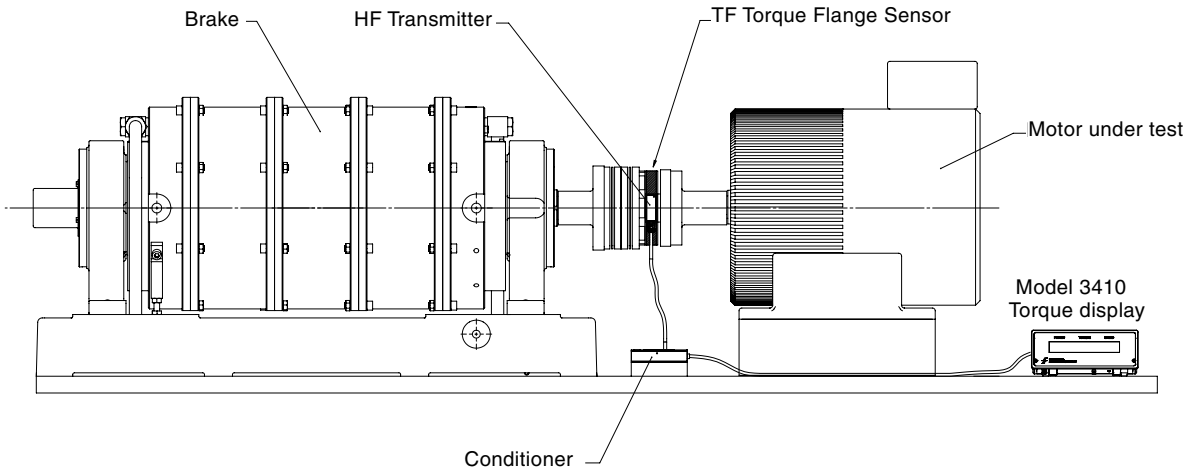
TF Torque Flange Sensors measure both static and dynamic torque on stationary and rotating shafts. They are used in general combustion engine, electric motor and gearbox test benches; and can also be mounted inline for active torque monitoring of transmissions, powertrains, wind generators, gas turbines, boat engines, etc.

Diagrams TF

BLOCK DIAGRAM



SYSTEM CONFIGURATION



Specifications TF

MODEL RATINGS

Model	Rated Torque	Overload Capacity	Accuracy Class	Maximum Speed	Number of Teeth **	Torsional Stiffness	Deformation Angle
	N·m	*% of R.T.*		*rpm*	*Z*	*N·m/rad*	*°*
TF 210	50	200%	0.1%	17,000	70	7.16×10^4	0.040
TF 211	100	200%	0.1%	17,000	70	1.25×10^5	0.046
TF 212	200	200%	0.1%	17,000	70	2.05×10^5	0.056
TF 213	500	200%	0.1% *	13,000	91	7.16×10^5	0.040
TF 214	1,000	200%	0.1% *	13,000	91	9.55×10^5	0.060
TF 215	2,000	200%	0.1% *	10,000	113	2.86×10^6	0.040
TF 216	5,000	200%	0.1%	8,000	133	7.16×10^6	0.040
TF 217	10,000	‡ 150%	0.1%	8,000	133	1.25×10^7	0.046
TF 218	20,000	200%	0.20% – 0.25%	3,000	283	2.86×10^7	0.040
TF 219	50,000	‡ 180%	0.20% – 0.25%	3,000	283	6.82×10^7	0.042
TF 220	100,000	‡ 180%	0.25% – 0.30%	3,000	270	3.37×10^8	0.017

Model	Sensor Weight ***	Moment of Inertia	
	kg	*kg·m²*	*lb·ft·s²*
TF 210	2.1	2.996×10^{-3}	2.211×10^{-3}
TF 211	2.2	3.172×10^{-3}	2.341×10^{-3}
TF 212	2.2	3.138×10^{-3}	2.316×10^{-3}
TF 213	3.3	7.803×10^{-3}	5.758×10^{-3}
TF 214	3.3	7.818×10^{-3}	5.769×10^{-3}
TF 215	5.2	1.868×10^{-2}	1.378×10^{-2}
TF 216	9.3	4.747×10^{-2}	3.503×10^{-2}
TF 217	9.3	4.706×10^{-2}	3.472×10^{-2}
TF 218	42.7	9.635×10^{-1}	7.109×10^{-1}
TF 219	43.3	9.724×10^{-1}	7.175×10^{-1}
TF 220	36.0	1.070×10^{0}	7.895×10^{-1}

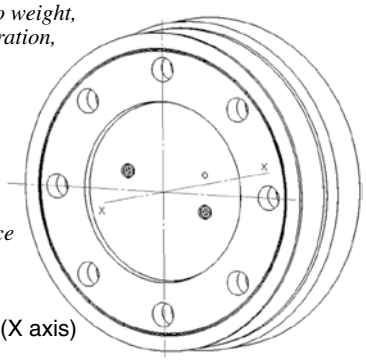
Available upon request:
- *Torque up to 150,000 N·m*
- *High speed versions*

* *Linearity-hysterese error 0.05% on request*

** *Inductive speed detection available on request.*

*** *Add 0.8 kg to 2.8 kg to weight, depending on configuration, for electronic devices attached to the sensor (transmitter, receiver, speed conditioner).*

‡ *Dynamic torque peak values for Models TF 217, TF 219 and TF 220 are due to force transmission limit of mounting screws.*



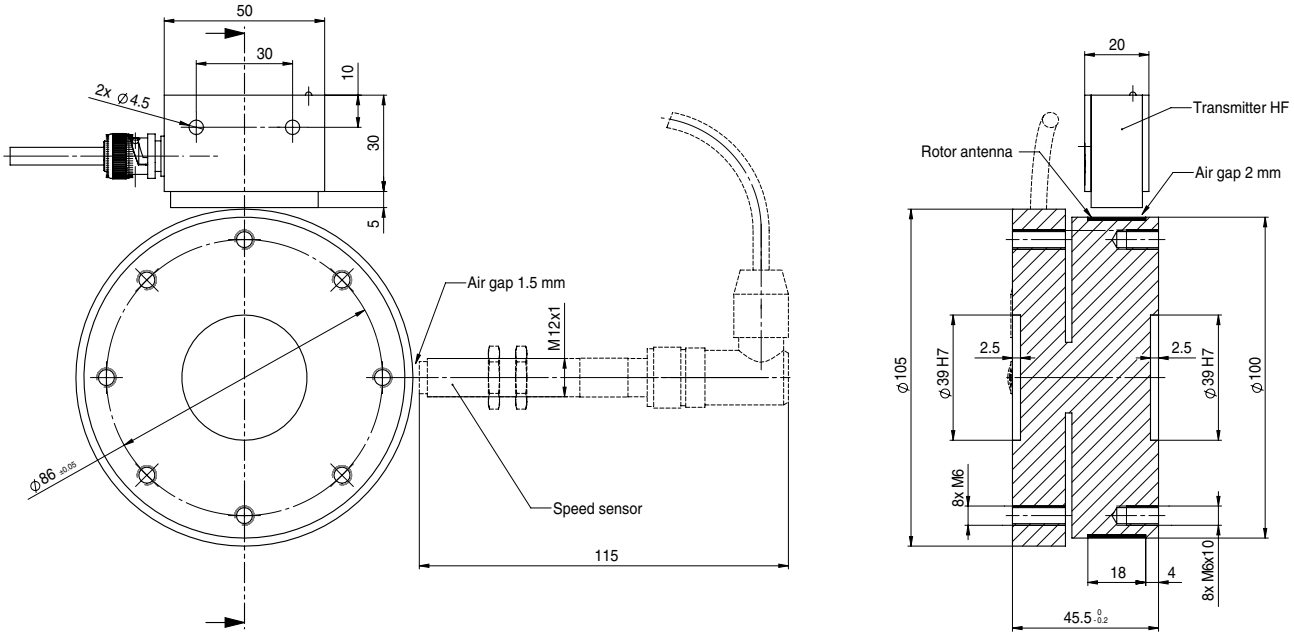
Moment of Inertia (X axis)

RATINGS COMMON TO ALL TF SENSORS

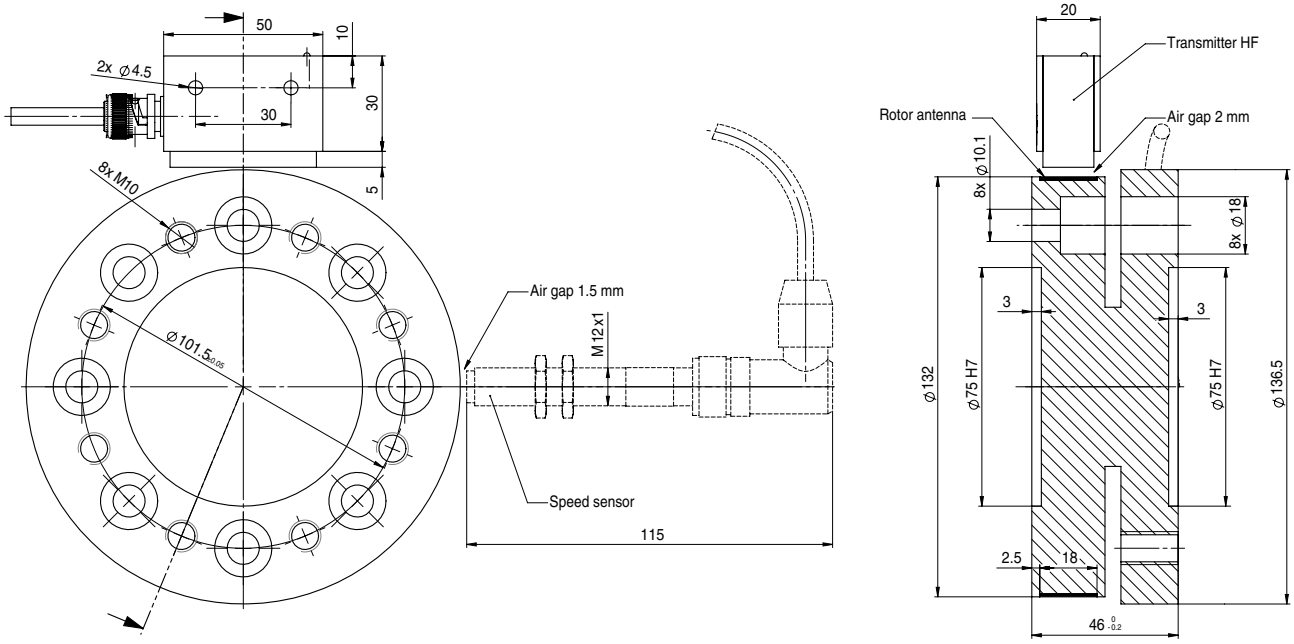
TORQUE MEASUREMENT	
Maximum Dynamic Torque Without Damage (Overload Limit)	400% of Rated Torque
SPEED MEASUREMENT (option)	
Number of Teeth	Depending on the size; Refer to Z under Model Ratings
Speed Pick-up Transducer	Magnetoresistive
Minimum Speed Detection	0.5 rpm
ENVIRONMENT	
Rated Temperature Range	+10 °C to +85 °C
Storage Temperature Range	-25 °C to +85 °C
Extended Temperature Range (option)	-30 °C to +125 °C
Temperature Influence on Zero	0.01% / °C
Protection Class	IP 42 (optional IP 54)
INPUT AND OUTPUT SIGNALS	
Power Supply	TF 209 – TF 217: 24 V DC ±10%, max 350 mA TF 218 – TF 220: 100–240 V AC
Torque Output Signal (rated / max)	±5 V DC / ±10 V DC
Passband Frequency	0 to 1 kHz (-3 dB)
Speed Output (option)	TTL (pulses per revolution corresponds with number of teeth)

Sensor Dimensions TF

TF 210 TO TF 212

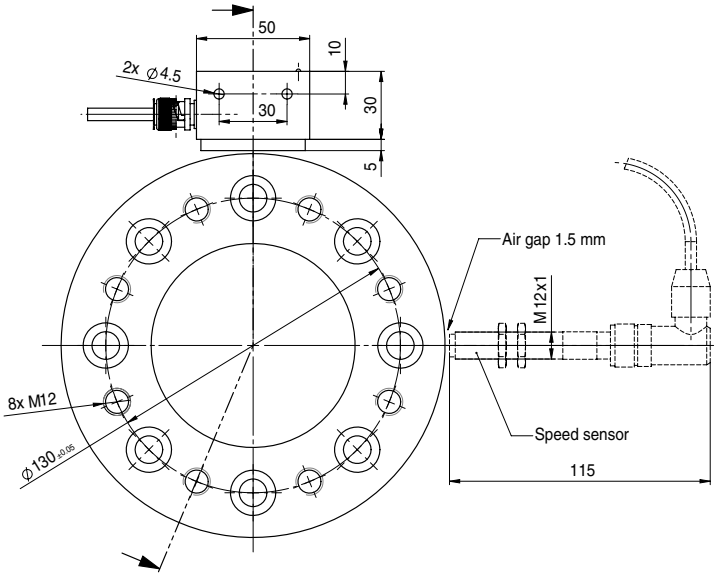


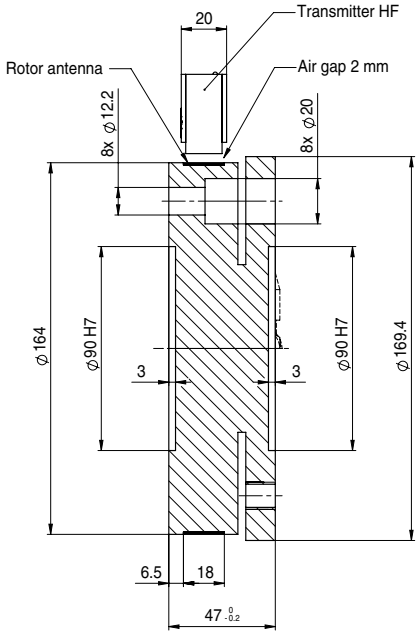
TF 213 AND TF 214



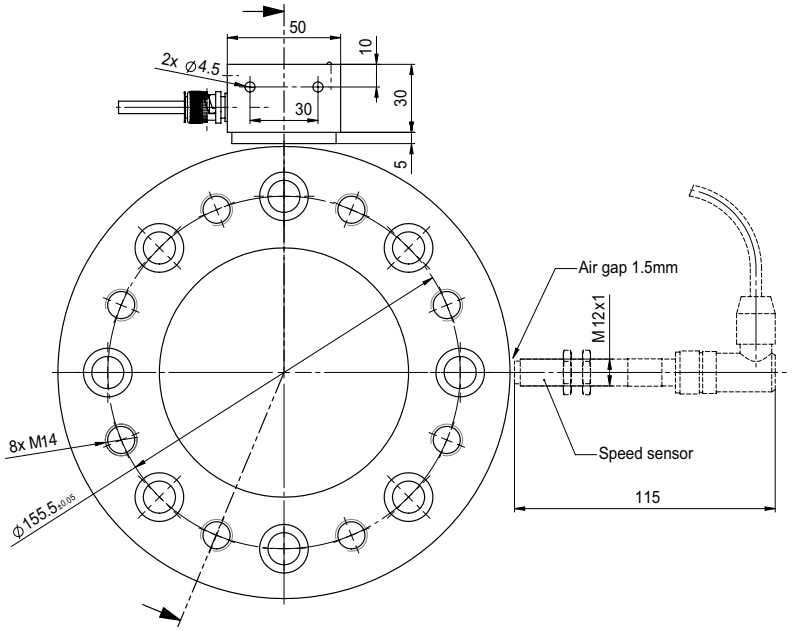
Sensor Dimensions TF

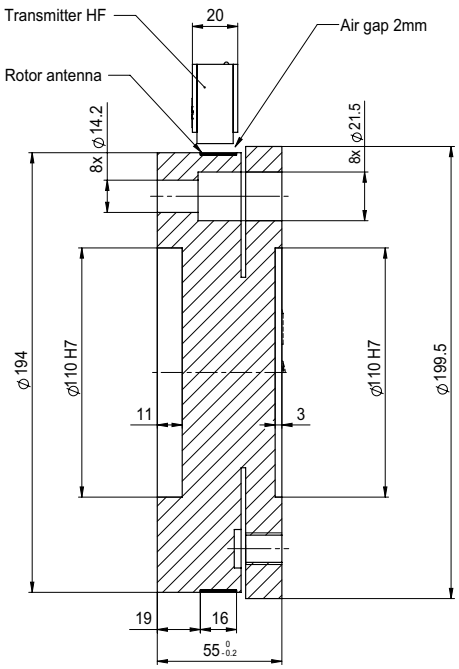
TF 215





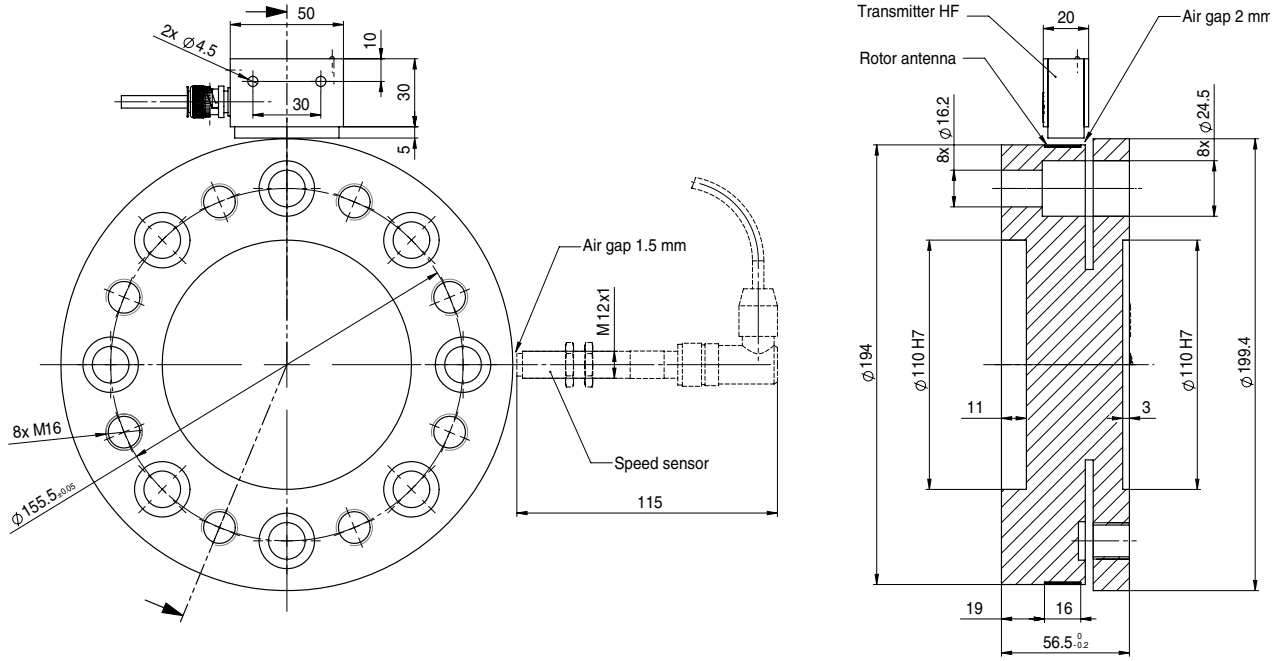
TF 216



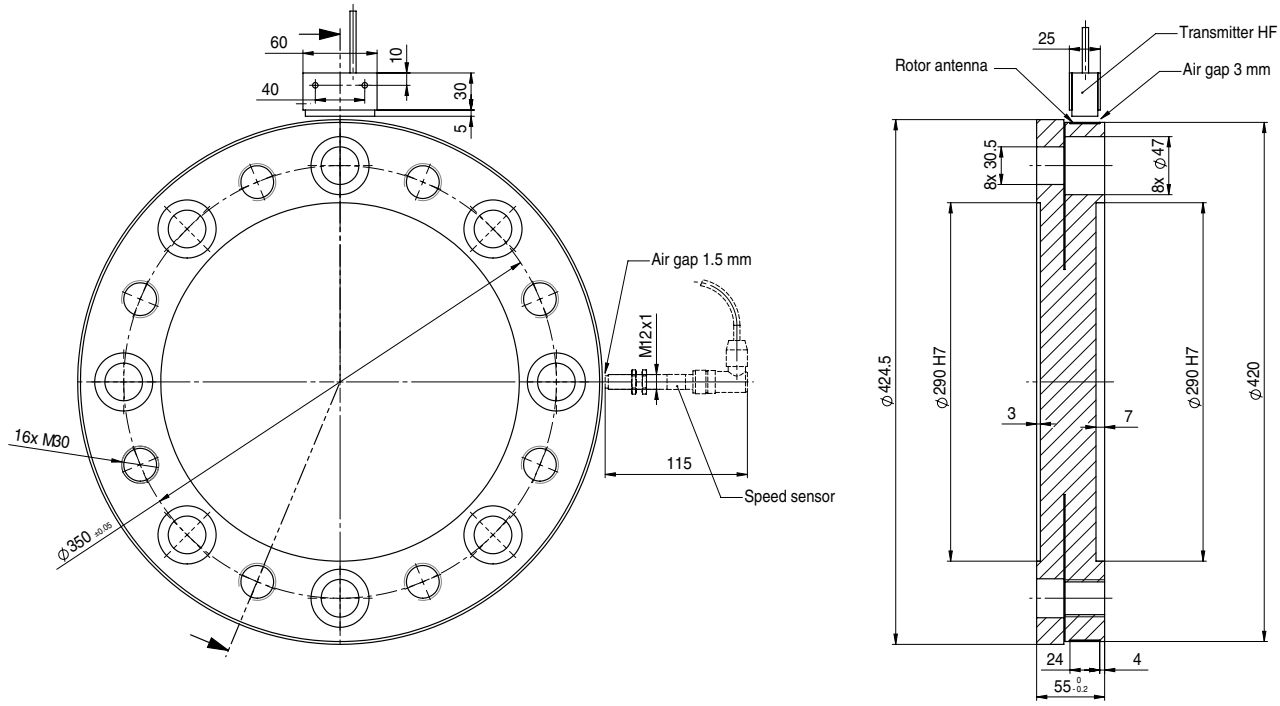


Sensor Dimensions TF

TF 217

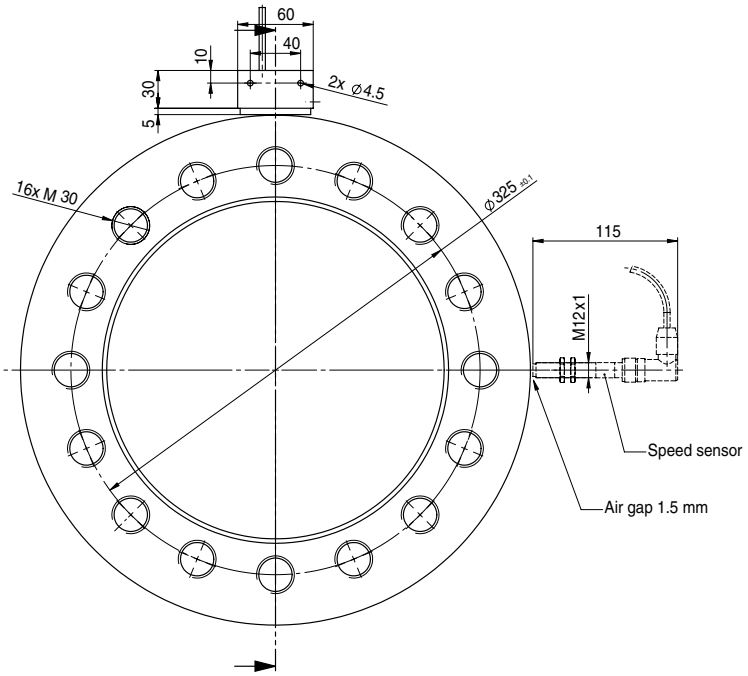


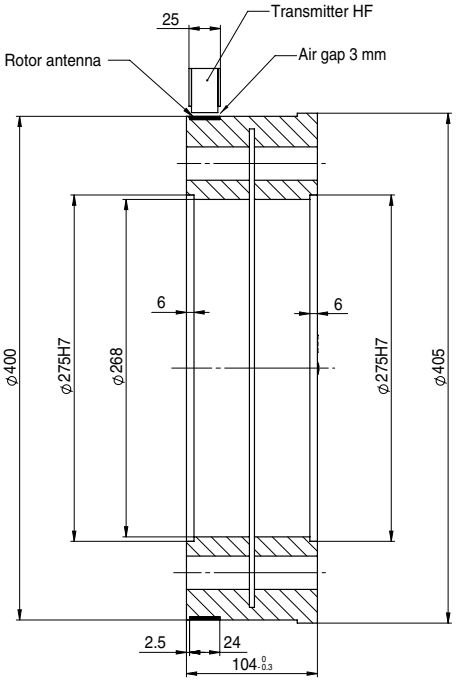
TF 218 AND TF 219



Sensor Dimensions TF

TF 220

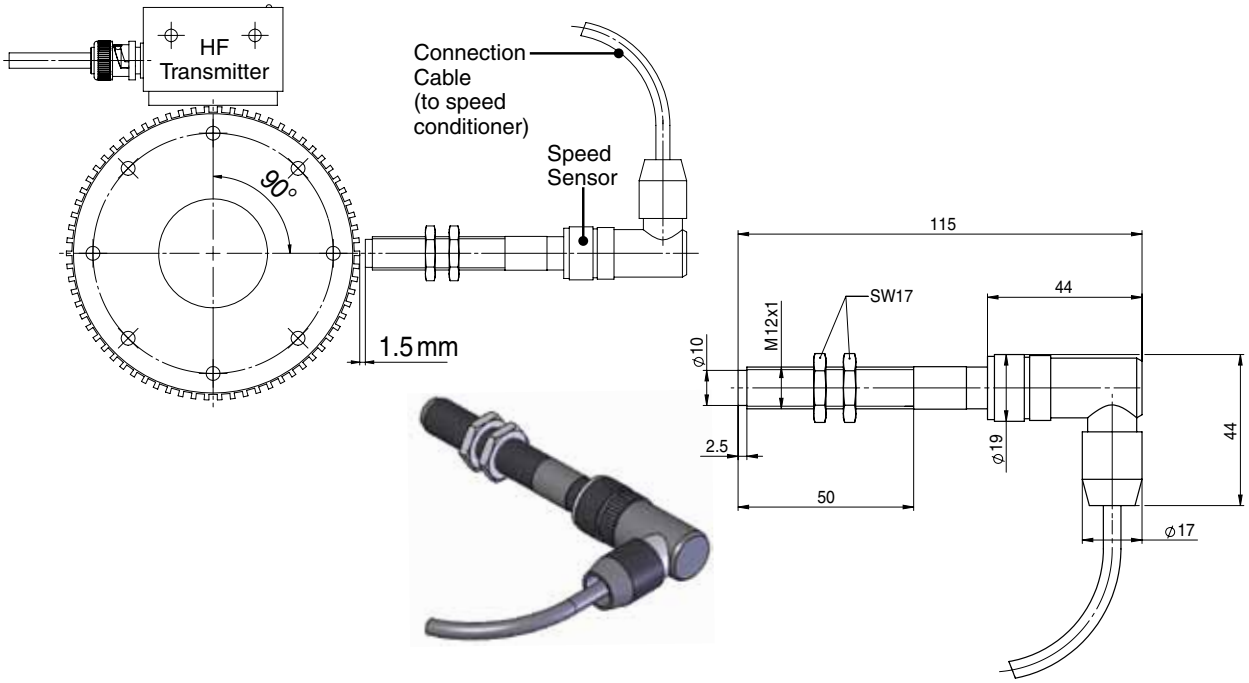




Speed Sensor Dimensions TF

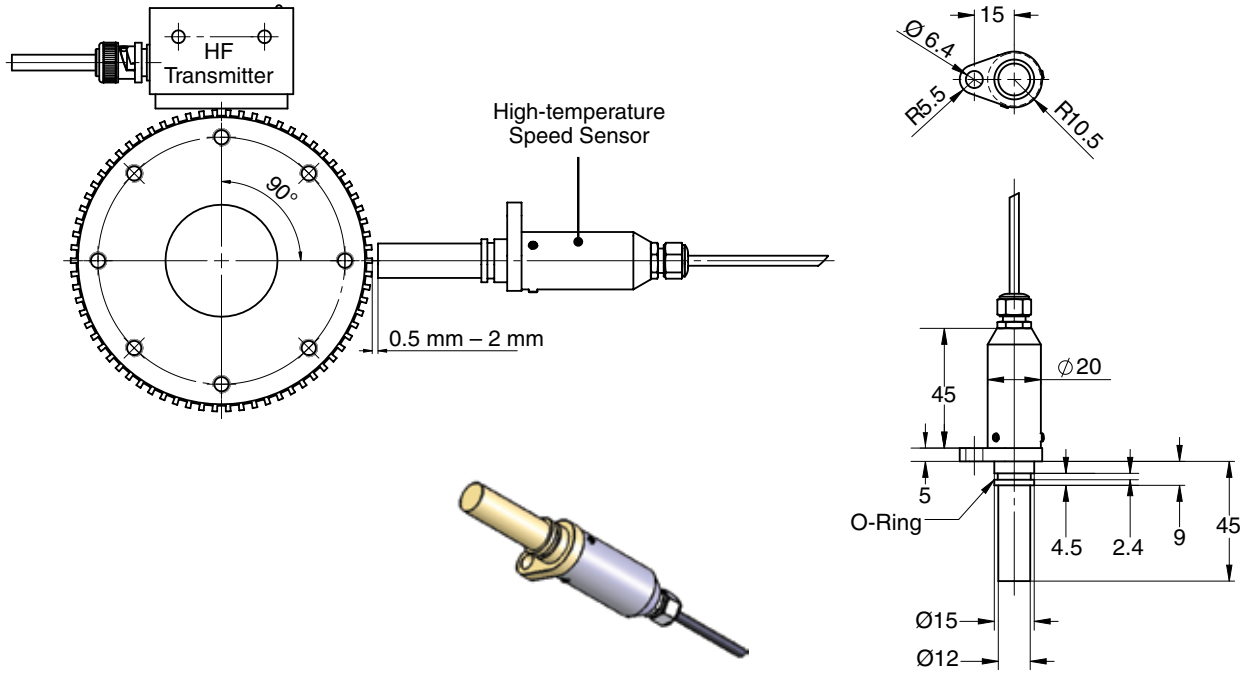
STANDARD SPEED SENSOR

The standard speed sensor is delivered with TF Torque Flange Sensors ordered with the speed measurement option.



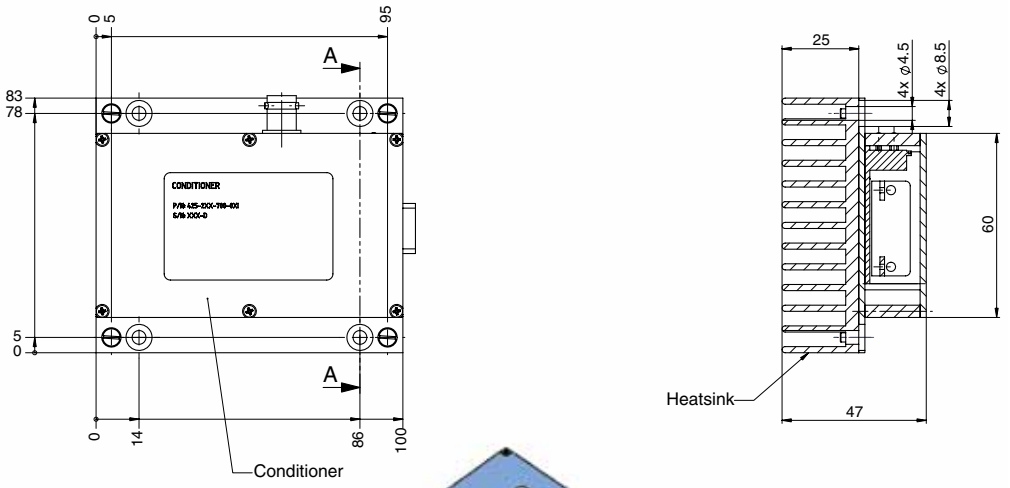
HIGH-TEMPERATURE SPEED SENSOR

The high-temperature speed sensor is delivered with TF Torque Flange Sensors ordered with both the speed measurement and extended temperature range options.



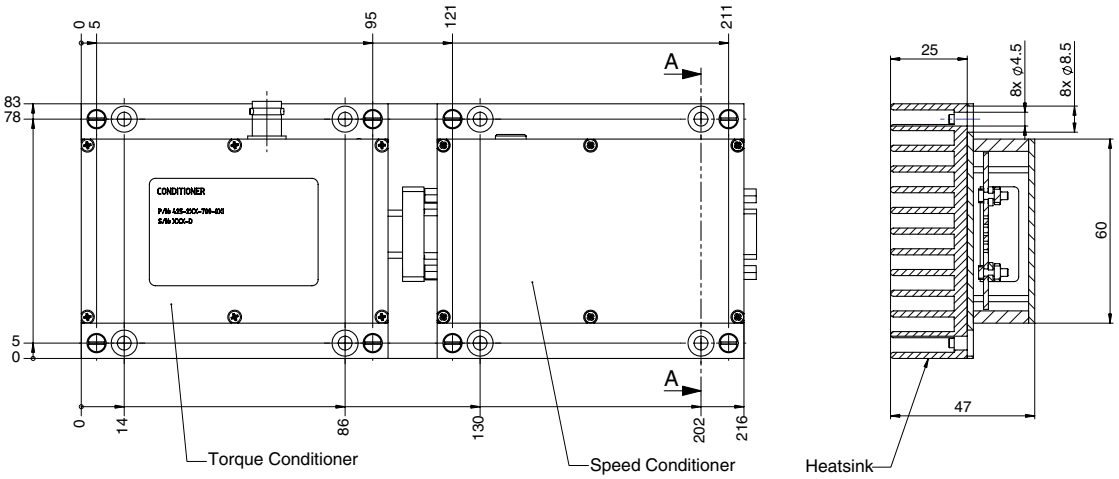
Conditioner Dimensions TF

TF 210 TO TF 217 - STANDARD



Conditioner - standard version (1.5 W)
mounted on heatsink for heat dissipation

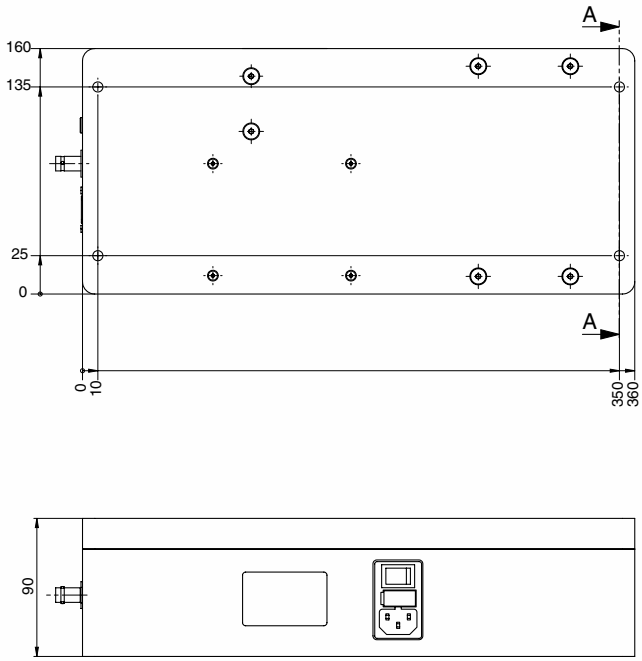
TF 210 TO TF 217 - WITH SPEED OPTION

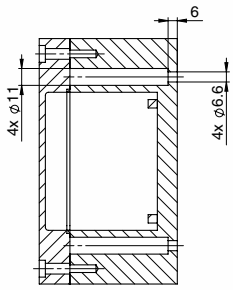


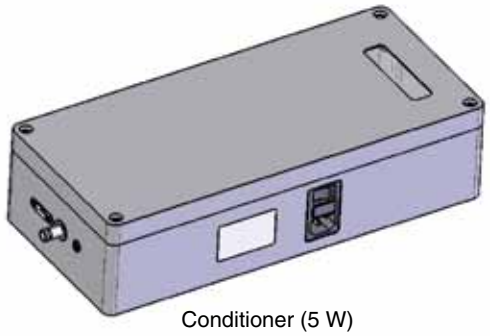
Conditioner - speed version (1.5 W)
mounted on heatsink for heat dissipation

Conditioner Dimensions TF

TF 218, TF 219 AND TF 220







Conditioner (5 W)
mounted inside electronics module

Ordering Information TF

OPTIONS AND ORDERING INFORMATION

MODEL NUMBER: TF 2□□/0□1

MODEL TF 2[1][0]– 2[2][0]

SPEED MEAUSUREMENT
- without (standard) — 1
- with (option) — 2

SYSTEM OPTIONS

Model 3410 Torque Transducer Display

Magtrol offers the new Model 3410 Display which supplies power to any TF Sensor and displays torque, speed and mechanical power. Features include:

- Adjustable English, metric and SI torque units
- Large, easy-to-read vacuum fluorescent display
- Built-in self-diagnostic tests
- Overload indication
- Tare function
- RS-232 interface
- Torque and speed outputs
- Closed-box calibration
- Includes Magtrol Torque 1.0 Software

Torque 1.0 Software

Magtrol's Torque 1.0 Software is an easy-to-use Windows® executable program, used to automatically collect torque, speed and mechanical power data. The data can be printed, displayed graphically or quickly saved as a Microsoft® Excel spreadsheet. Standard features of Magtrol's Torque 1.0 Software include: peak torque capture, multi-axes graphing, measured parameter vs. time, adjustable sampling rates and polynomial curve fitting.

Connection Cables

MODEL NUMBER: ER 1□□-0□

CABLE END
- 14-Pin Connector — 16
  (For use with 3410 Display or DSP6001 Controller)
- Pigtail Wires — 17

CABLE LENGTH
- 5 m — 1
- 10 m — 2
- 20 m — 3

Couplings

For the TF 210 – TF 219 Torque Flange Sensors, Magtrol offers double-element high-speed couplings to provide compensation for axial, angular and radial misalignments. Engaged by friction, they are torsionally-stiff and minimize reaction forces. BSD 9200 Series couplings are wear and maintenance-free and feature a compact design.

TF Torque Sensor	BSD Moduflex® 9200 Couping
TF 210 to TF 211	BSD 9200-2.8-200
TF 212	BSD 9200-4.5-200
TF 213 and TF 214	BSD 9200-17-200
TF 215	BSD 9200-28-200
TF 216	BSD 9200-64-200
TF 217	BSD 9200-110-200
TF 218 and TF 219	BSD 9200-640-200

Due to the continual development of our products, we reserve the right to modify specifications without forewarning.

2. Installation / Configuration

CAUTION: BEFORE COMPLETING THE ASSEMBLY AND MOUNTING, IT IS ADVISED TO FIRST POWER UP THE SYSTEM *(SEE SECTION 3.1)* IN ORDER TO CHECK THE SIGNAL TRANSMISSION.

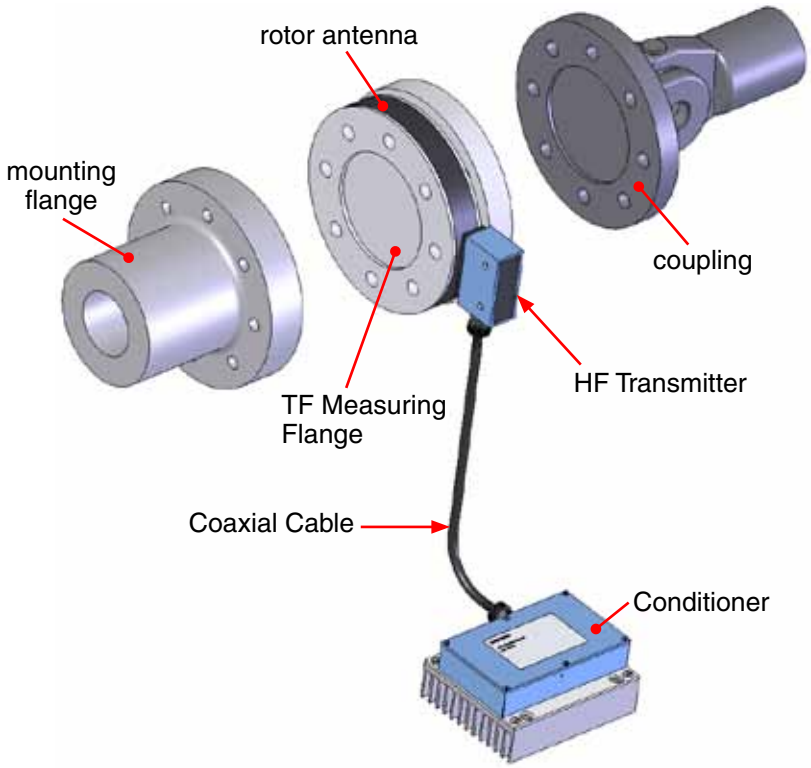


Figure 2–1 Installation Overview

2.1 INITIAL CLEANING

Prior to installing the TF Series Torque Flange Sensor, all contact surfaces including the measuring flange, coupling element and mounting flange must be carefully cleaned and degreased. This will guarantee optimal transmission of the measured torque signal.

Use a soft cloth lightly dampened with alcohol to avoid any abrasion. Be careful to prevent any alcohol from entering the flange or coming in contact with the rotor antenna during cleaning.

CAUTION: AVOID ANY USE OF OVERLY AGGRESSIVE SOLVENTS. THESE CAN DAMAGE THE ROTOR ANTENNA WHILE CLEANING. IF NECESSARY, ACETONE MAY BE USED (INSTEAD OF ALCOHOL) TO REMOVE ENCRUSTED DEPOSITS.

It is advised to clean all flange and coupling contact surfaces each time the drive train is reconfigured.

2.2 MEASURING FLANGE MOUNTING

2.2.1 ALIGNMENT

The TF Series Torque Flange Sensors are easy to install by design. However, it is important to achieve the best possible alignment of the various components of the measurement drive train. Angular and radial misalignments (as illustrated below) must be avoided.

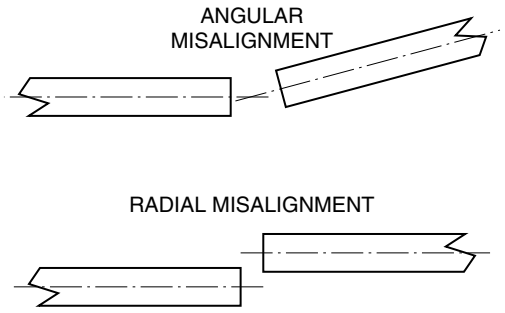


Figure 2–2 Angular and Radial Misalignment

The admissible angular and radial misalignment is 0.3° and 0.04 mm, respectively. By using proper couplings, modest misalignments can be compensated.

2.2.2 COUPLING SELECTION

To avoid excessive extraneous loads, do not couple the driving elements directly to the driven part of the measuring chain by means of the measuring flange. A coupling is necessary.

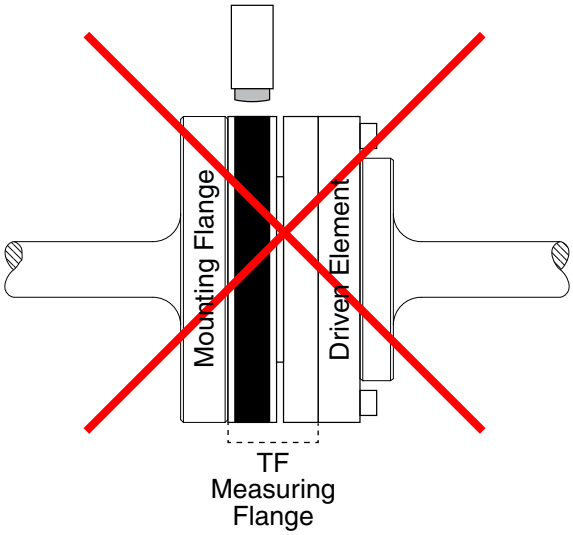


Figure 2–3 Incorrect Mounting

2.2.2.1 Couplings for Angular Misalignment

In case of a slight angular error, a one-piece lamella coupling, cardan shaft or bellows coupling may be used.

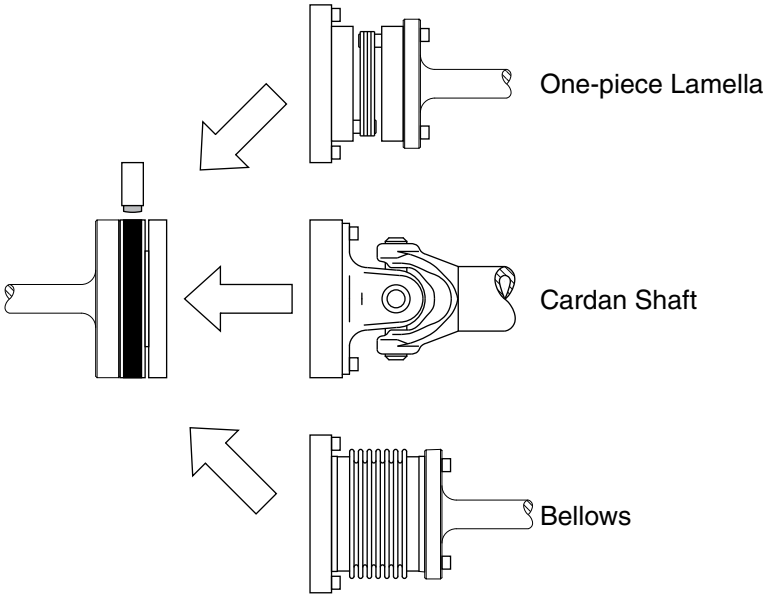


Figure 2–4 Coupling Options for Angular Misalignment Correction

2.2.2.2 Couplings for Radial Misalignment

If the shaft mounting shows a slight radial misalignment, a two-piece lamella coupling, double cardan shaft or bellows coupling may be used. These elements provide the system with two degrees of freedom in order to compensate for a slight radial misalignment.

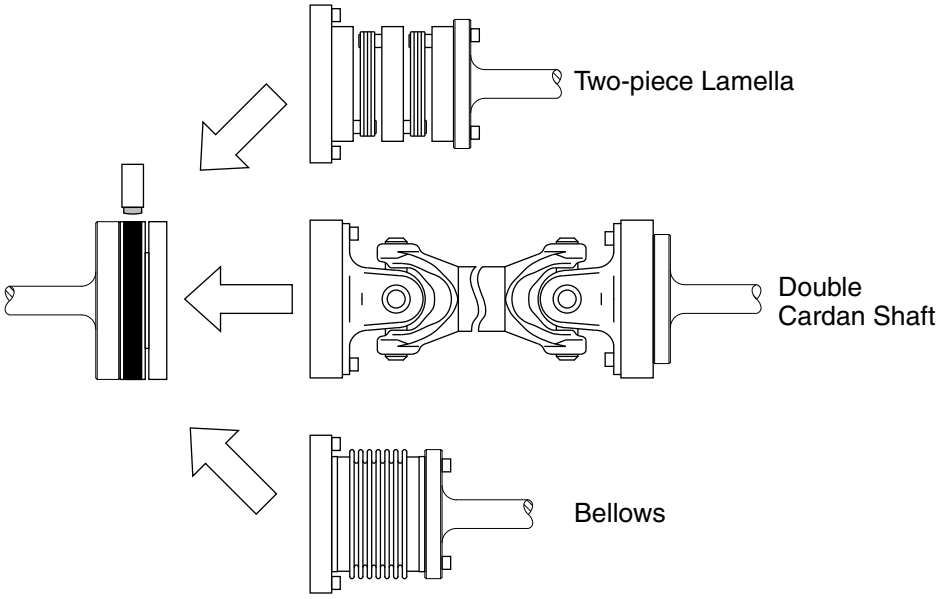


Figure 2–5 Coupling Options for Radial Misalignment Correction

2.2.3 MOUNTING CONSIDERATIONS

Mounting Flange and Coupling Specifications	
Minimum Tensile Strength	700 N/mm²
Minimum Hardness	25 HRC
Roughness	Ra 1.6
Minimum Face Flatness	0.03 mm
Centering Tolerance Ø	g6

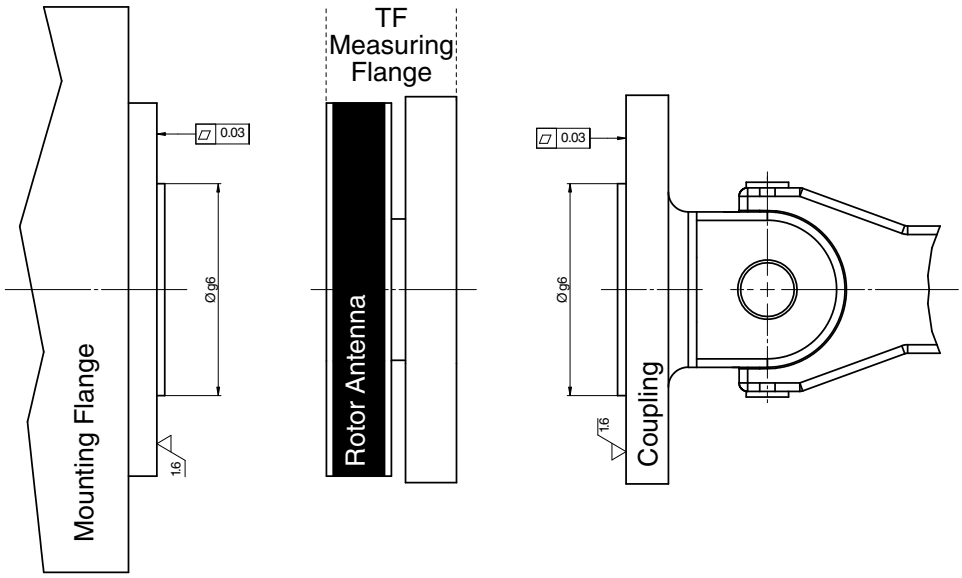


Figure 2–6 Mounting Flange and Coupling Specifications

- The mounting flange or coupling mounted on the same side as the rotor antenna must have a diameter equal to or smaller than the rotor antenna diameter.
- To achieve the best possible centering of the measuring flange, the mounting flanges and couplings should use a centering device with a g6 tolerance on the outside diameter as illustrated in *Figure 2–6 Mounting Flange and Coupling Specifications*.

  The measuring flange is fitted with a centering bore (tolerance H7) on each face.

Note: If the mounting flange is also fitted with a centering bore, an intermediate centering washer may be used (see *Figure 2–8 Mounted TF*).

- A minimum distance of 10 mm between the main body of the mounting flange and its center piece (as illustrated in *Figure 2–7 Measuring Flange Spacing*) is necessary to avoid any disturbance when transmitting the HF telemetry signal.

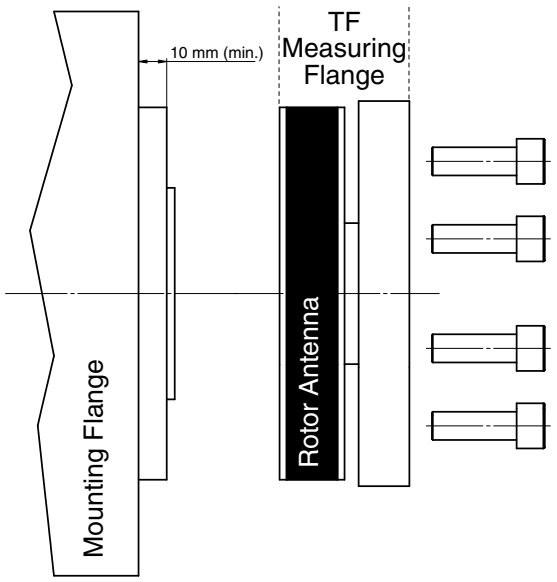


Figure 2–7 Measuring Flange Spacing

- Check the lengths of the screws and be sure to avoid any contact between the screws and the opposite part of the measuring flange (see *Figure 2–8 Mounted TF*).
- Ensure a 0.1 to 0.2 mm clearance between the centering hole of the measuring flange and the mounting flange centering washer.

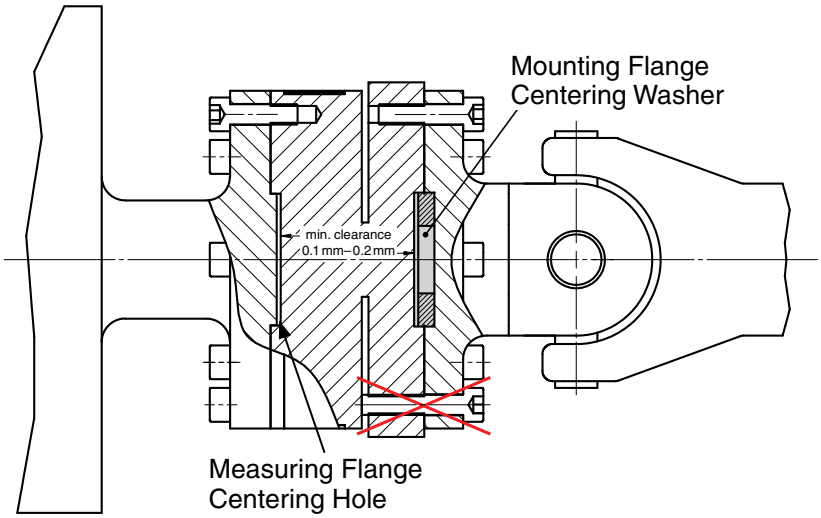


Figure 2–8 Mounted TF

2.2.4 Mounting Procedure

Since all TF Sensors are reversible, the component that is to be mounted on the same side as the measuring flange's rotor antenna must be mounted first. The options/mounting orders are as follows:

Option	First Step	Second Step
A	Mounting Flange to Measuring Flange (see *Section 2.2.4.2)*	Coupling to Measuring Flange/Mounting Flange Assembly (see *Section 2.2.4.3)*
B	Coupling to Measuring Flange (see *Section 2.2.4.4)*	Mounting Flange to Measuring Flange/ Coupling Assembly to (see *Section 2.2.4.5)*

2.2.4.1 Mounting Screws

The measuring flange must be mounted with 8.8/10.9/12.9 quality screws applying the specific fastening torque listed in the following table.

TF Sensor Model	Fastening Screw Size	Screw Class	Fastening Torque [*N·m*]	
			Friction Coefficient μ = 0.10	Friction Coefficient μ = 0.14
TF 209	M6	8.8	9.0	11.3
TF 210				
TF 211	M6	10.9	13.2	16.5
TF 212				
TF 213	M10	10.9	63	79
TF 214				
TF 215	M12	10.9	108	137
TF 216	M14	12.9	201	255
TF 217	M16	12.9	309	395
TF 218	M30	10.9	1775	2274
TF 219				
TF 220	M30	10.9	1775	2274

The mounting screws must be tightened in the following order.

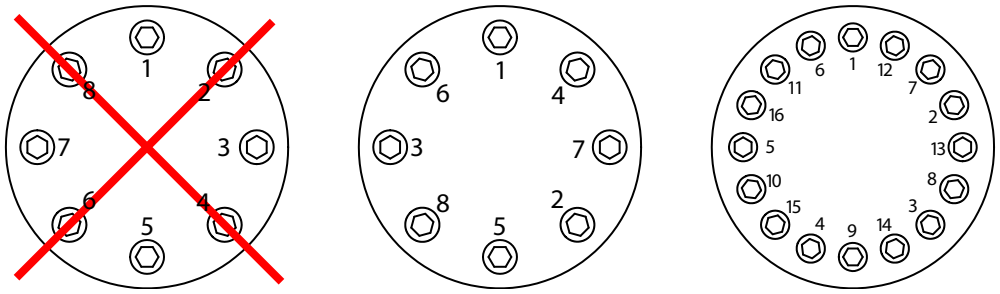


Figure 2–9 Screw Tightening Order

Note: When faced with alternating loads, secure the screws in their threads with thread locker in order to avoid any loss of preload. Be sure to prevent the thread locker from spilling over.

2.2.4.2 Attaching the Mounting Flange to the Measuring Flange

Screw the measuring flange onto the mounting flange, firmly attaching it to the driving shaft, as shown in the figures below.

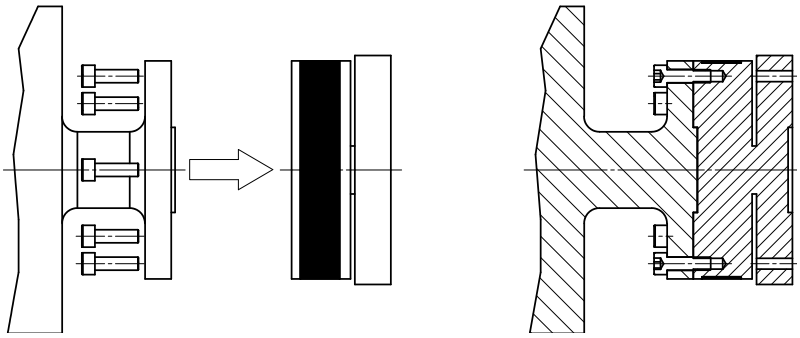


Figure 2–10 Flange Mounting of TF 209 to TF 212 and TF 220 Sensors

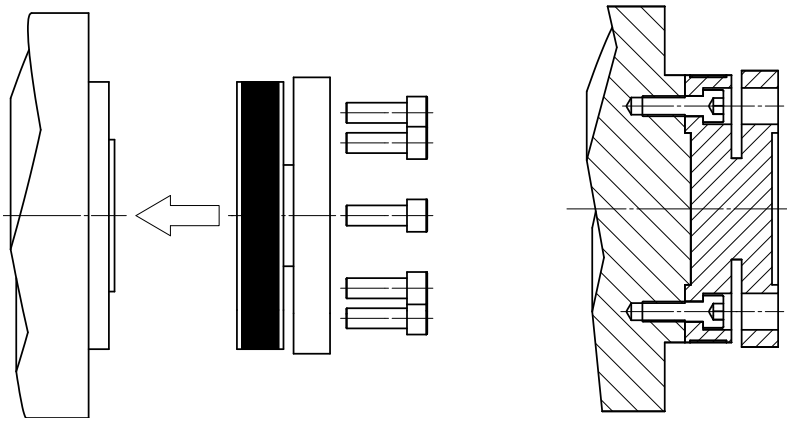


Figure 2–11 Flange Mounting of TF 213 to TF 219 Sensors

2.2.4.3 Attaching the Coupling to the Measuring Flange/Mounting Flange Assembly

Screw the single- or double-element coupling, or cardan shaft, onto the measuring flange.

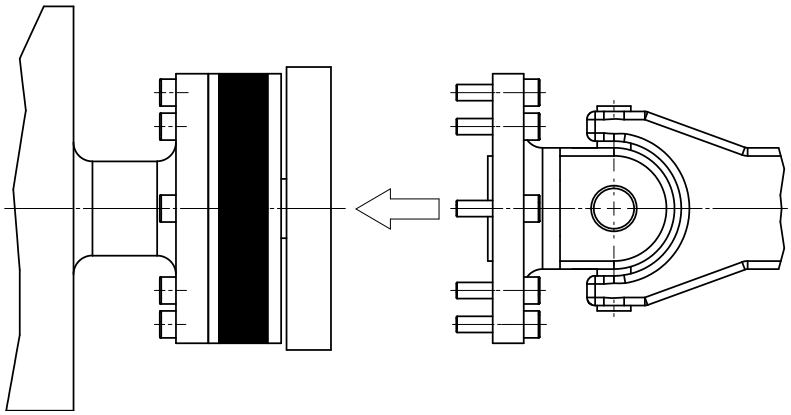


Figure 2–12 Coupling Mounting to Measuring Flange/Mounting Flange Assembly

2.2.4.4 Attaching the Coupling to the Measuring Flange

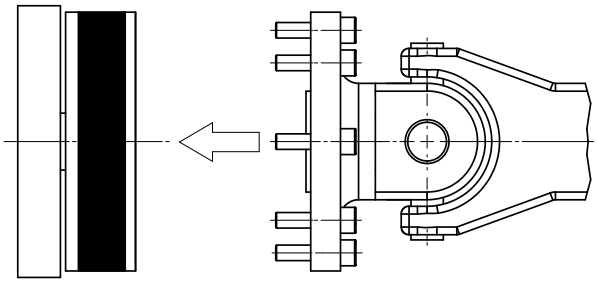


Figure 2–13 Coupling Mounting to Measuring Flange (TF 209, 210, 211 and 220)

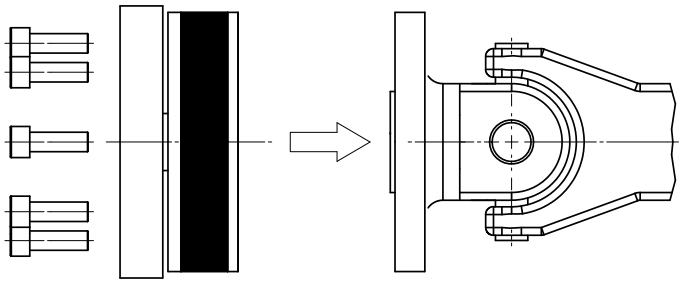


Figure 2–14 Coupling Mounting to Measuring Flange (TF 213 – 219)

2.2.4.5 Attaching the Mounting Flange to the Measuring Flange/Coupling Assembly

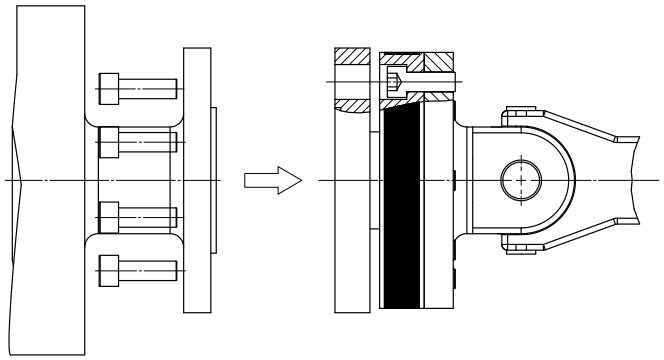


Figure 2–15 Mounting Flange to Measuring Flange/Coupling Assembly

Note: When using a cardan shaft, Magtrol recommends the latest generation of GKN series 687 cardan shafts with limited weight. Do not use the over weighted old cardan shafts. Proper mounting position of the cardan shaft is neccessary to ensure proper balancing. Standard applications using a cardan shaft should not exceed 1500-2000 rpm, depending on size and deflection angle.

2.3 HF TRANSMITTER MOUNTING

Mount the HF transmitter according to the following specifications:

- The HF transmitter must be perfectly centered (laterally) with the rotor antenna and also aligned with the measuring flange axis.
- A gap of 2 mm for TF 209 to TF 217 Sensors and 3 mm for TF 218 to TF 220 Sensors must be maintained between the HF transmitter and rotor antenna in order to guarantee the best possible signal transmission.
- The HF transmitter must be mounted onto a support which can be easily adjusted both horizontally and vertically. To prevent any disturbance of the transmitted signal, the support must be at least 10 mm away from the HF transmitter rim (see *Figure 2–16 HF Transmitter Installation*). The support must also be stable in order to prevent excessive vibrating of the HF transmitter and, consequently, avoid electromagnetic coupling problems between the rotor antenna and the HF transmitter.

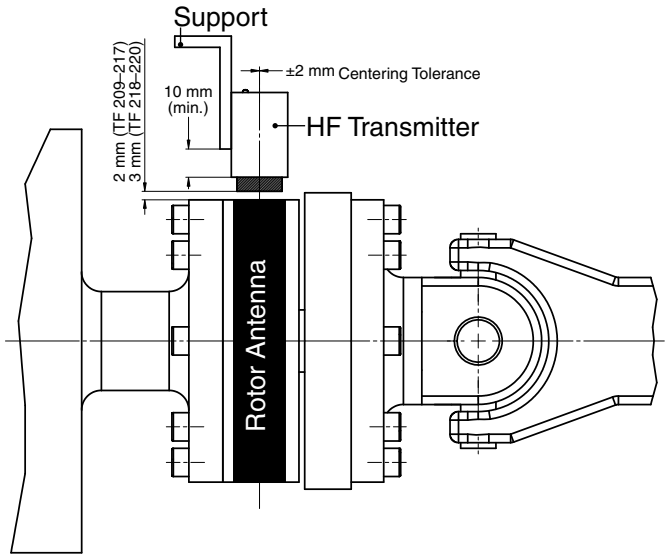


Figure 2–16 HF Transmitter Installation

2.4 SPEED SENSOR MOUNTING

If the TF Torque Flange Sensor is ordered with optional speed measurement capabilities, the HF Transmitter and the speed sensor must be mounted offset from each other with at least a 90° angle, as shown in *Figures 2–17* and *2–18*.

2.4.1 Standard Sensors

The speed sensor must be placed at a 1.5 mm distance from the measuring flange in order to optimize detection.

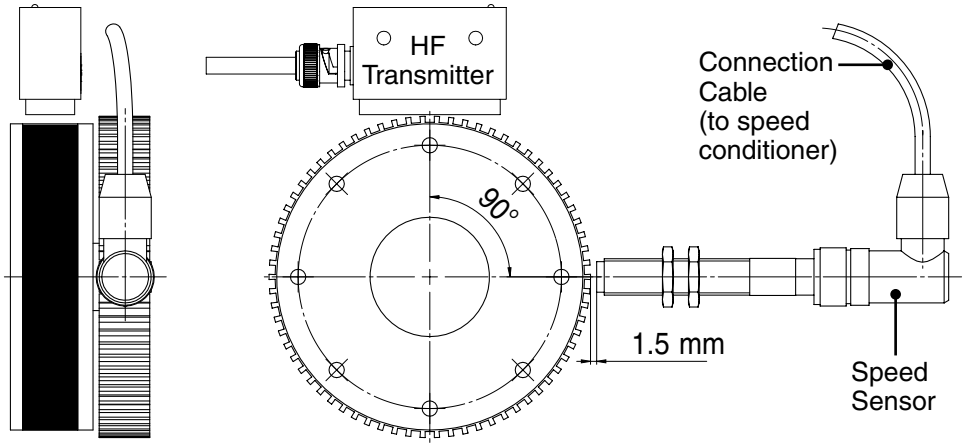


Figure 2–17 Standard Speed Sensor Installation

2.4.2 High-temperature Sensors

The high-temperature speed sensor, delivered with TF Torque Flange Sensors ordered with extended temperature range, must be placed at a 0.5 mm to 2 mm distance from the teeth with a 10° angle to optimize detection.

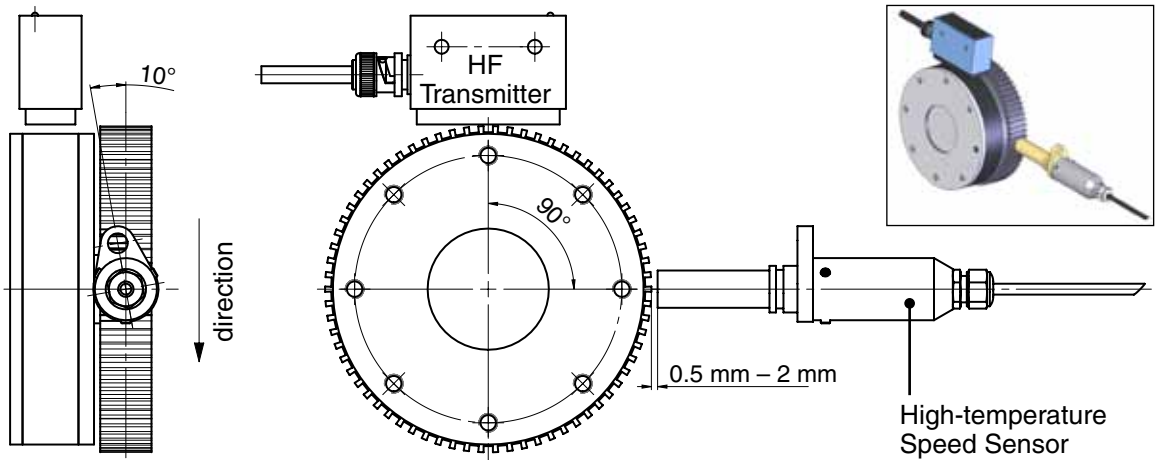


Figure 2–18 High-temperature Speed Sensor Installation

2.5 ELECTRICAL CONNECTIONS

Having installed the measuring flange and HF transmitter, only two electrical cables (three, with speed measurement option) need to be connected for the system to be operational.

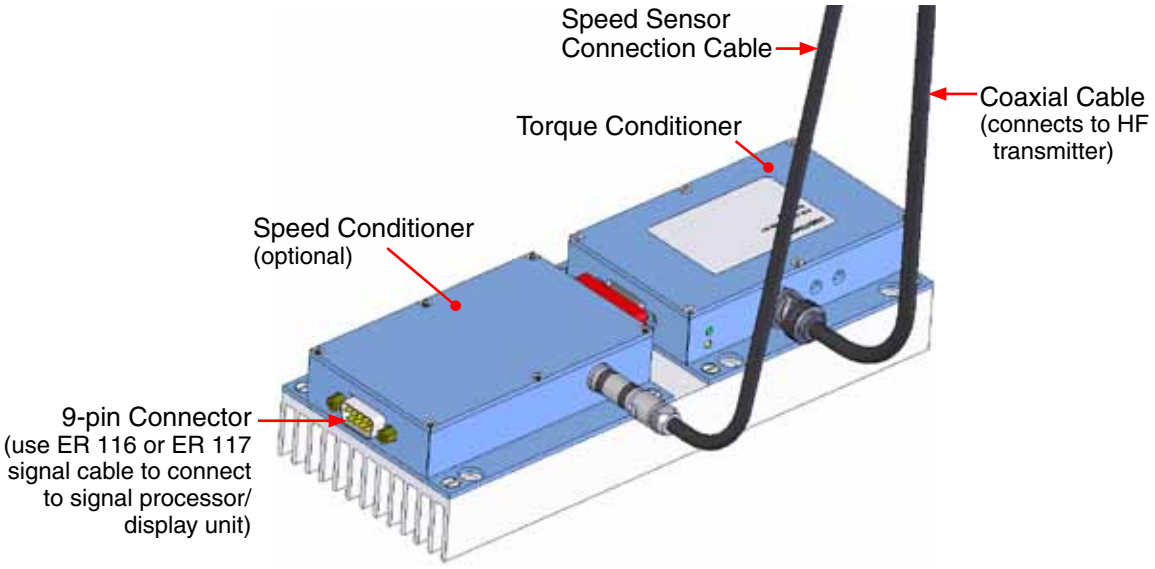


Figure 2–19 Conditioner Connections

Avoid running the ER-116/117 signal cable, coaxial cable and speed sensor connection cable through an environment which may be perturbed by electromagnetic fields. These cables should also not be run close to transformers, electric motors or motor drives. If running these TF Torque Flange Sensor cables through such environments cannot be avoided, a minimum distance of 2 feet from potentially perturbing components should be respected.

Ideally, these cables should be housed in steel conduit and connected to earth ground, to protect them as much as possible from electromagnetic perturbations.

2.5.1 CONNECTING THE HF TRANSMITTER TO THE CONDITIONER



CAUTION: NEVER SHORTEN THE COAXIAL CABLE. THE SYSTEM HAS BEEN TUNED IN ORDER TO OPTIMIZE THE HF TRANSMISSION USING THE COAXIAL CABLE'S ORIGINAL LENGTH (AS DELIVERED).

Connect the HF transmitter to the conditioner with the supplied coaxial cable, utilizing the dedicated connectors. (See *Figure 2–19 Conditioner Connections*.)

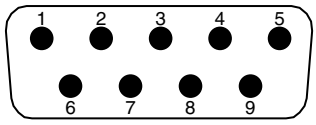
2.5.2 CONNECTING THE (OPTIONAL) SPEED SENSOR TO THE SPEED CONDITIONER

Connect the speed sensor to the speed conditioner with the supplied connection cable, utilizing the dedicated connectors. (See *Figure 2–19 Conditioner Connections*.)

2.5.3 Connecting the Conditioner to a Signal Processor/Display Unit

2.5.3.1 Conditioner Connector

For connection to a signal processor/display unit such as a Magtrol 3410 Torque Display or DSP6001 Controller, the conditioner is equipped with a 9-pin D-sub connector.



1. Torque signal (-5 to +5 V DC)
   (-10 to +10 V DC for 200%)
2. Torque signal grounding 0 V DC
3. Calibration signal
4. N/C
5. Power supply grounding 0 V DC
6. TTL speed signal (*with speed measurement option*)
7. Power supply 24 V DC (±10%) (N/C for 5W conditioner)
8. N/C
9. N/C

Figure 2–20 Conditioner Connector Pin Configuration

2.5.3.2 Signal Cables

Magtrol offers two cable options for connecting the TF Torque Flange Sensor to a signal processor/ display unit *(sold separately)*.

Cable Model	Connectors	
	On Conditioner Side	On Display Side
ER 116	9-pin D-sub connector	14-pin Centronics connector
ER 117	9-pin D-sub connector	none (only pigtail wires)

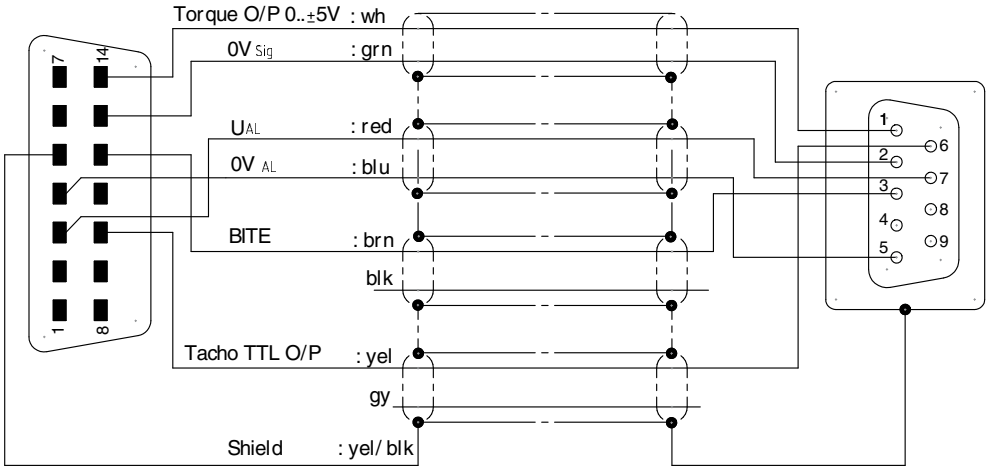


Figure 2–21 ER 116 Cable Configuration

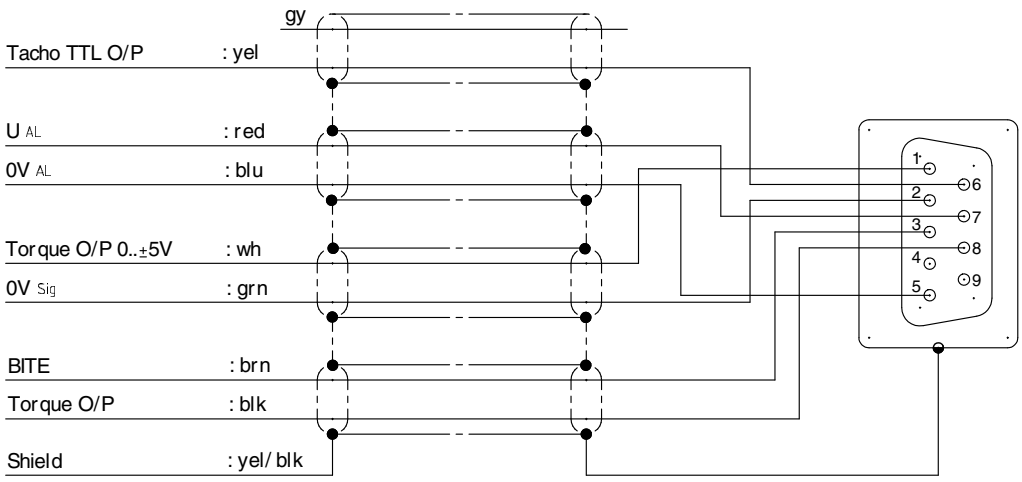


Figure 2–22 ER 117 Cable Configuration

2.6 PROTECTIVE SYSTEMS



WARNING! ALL ROTATING PARTS MUST BE FITTED WITH A PROTECTIVE SYSTEM TO ENSURE THAT THE USER, AS WELL AS ALL OTHER SURROUNDING PEOPLE AND OBJECTS, WILL NOT BE INJURED OR DAMAGED AS A RESULT OF THE DRIVE ELEMENT BECOMING BLOCKED, A TORQUE OVERLOAD, OR ANY OTHER POTENTIAL PROBLEM.

The following precautions concerning protective equipment of the drive train must be observed:

- Protective elements must prevent access to moving parts (during test).
- Protective elements must cover all parts which can cause crushing or cutting, and protect against projections of parts having become loose.
- Avoid attaching protective elements to rotating parts.
- A minimum space of at least 12 mm should be maintained between rotating parts and protective elements.

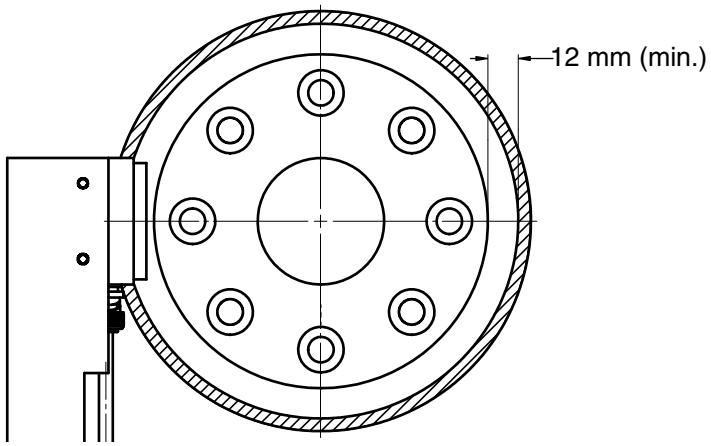


Figure 2–23 Spacing Between Flange and Guard

Figure 2–24 shows a good example of a protective system. All parts of the bench are accessible, but the cover prevents any risk to the user when closed.

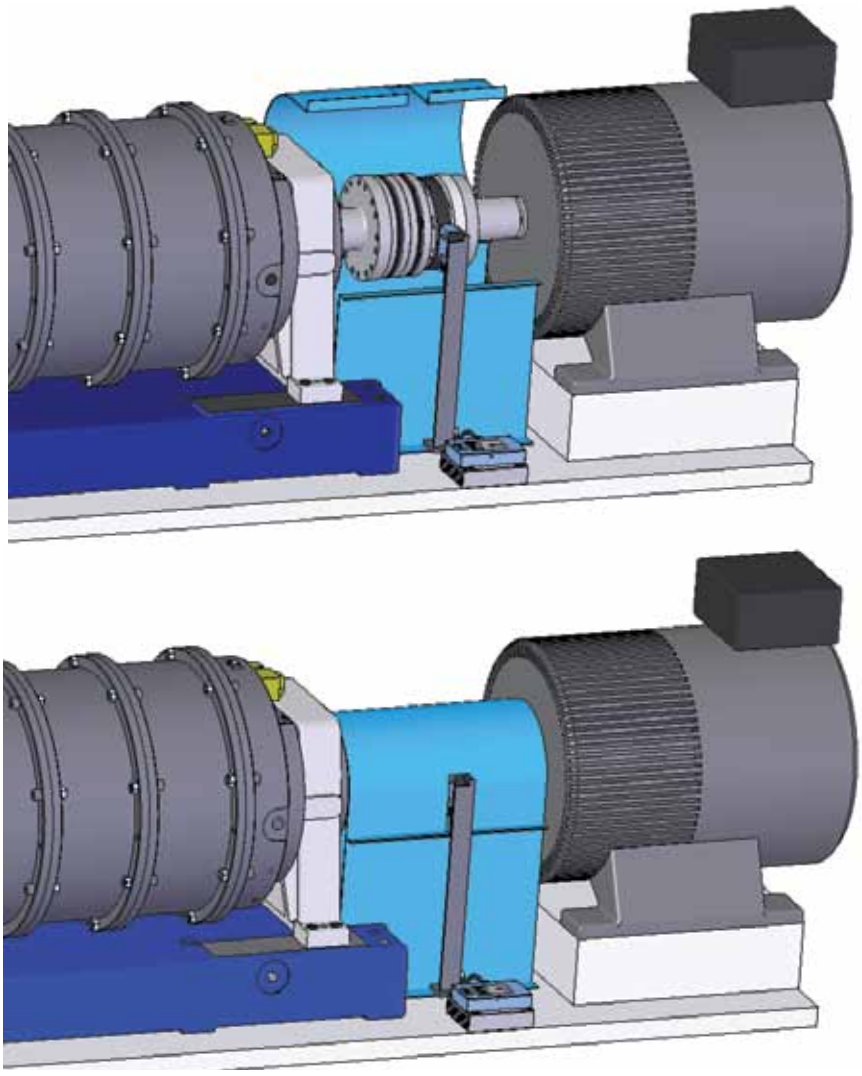


Figure 2–24 Example of Protective System

3. Startup

3.1 POWERING UP THE SYSTEM

1. Switch the system on (power up).
2. Check that all LEDs are illuminated. (If this is not the case, refer to *Section 6.2 – LED Indicators*).

LED	Indicates
Yellow	Conditioner is powered up.
Green	Conditioner receives a (return) signal. Data transmission is OK.
Red	HF transmitter is powered up.

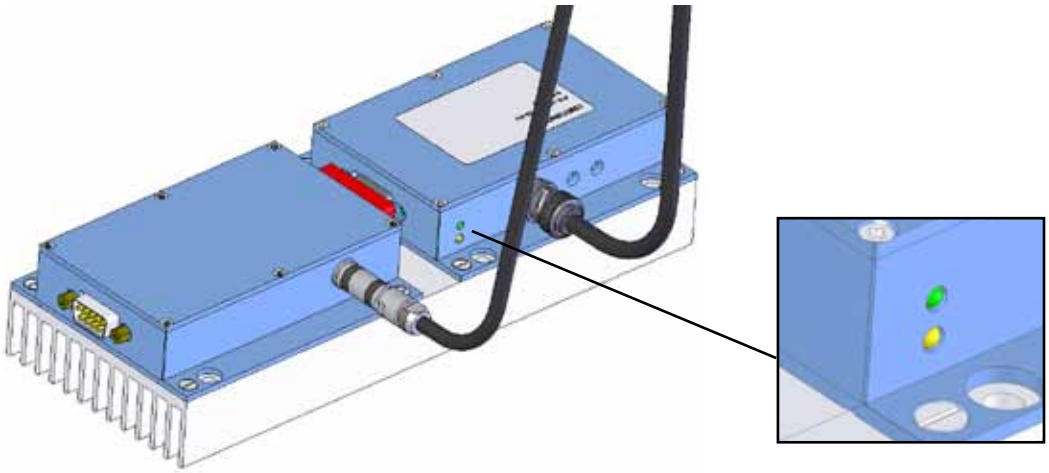


Figure 3–1 Green and Yellow LEDs

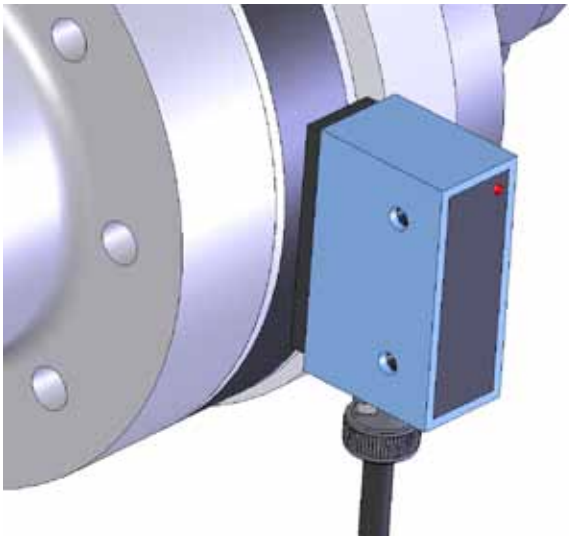


Figure 3–2 Red LED

3.2 OFFSET AND GAIN

Offset and gain of TF Series Torque Flange Sensors are calibrated before delivery. However the zero (offset) may have drifted slightly after mounting the measuring flange (surface flatness, fastening torque of the screws, parasitic forces).

If necessary, proceed as follows:

1. Completely unload the measuring chain (no force should be applied to the TF Sensor).
2. Adjust the torque output signal by means of the "Offset" potentiometer placed inside the conditioner in order to obtain a zero value for the torque (0 N·m = 0.000 V).

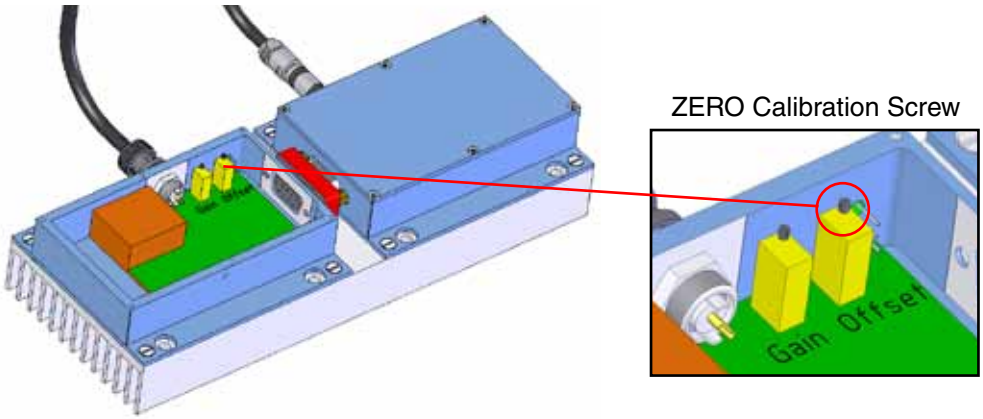


Figure 3–3 Zero Calibration of 1.5 W Conditioner (TF 209 to TF 217 Sensors)

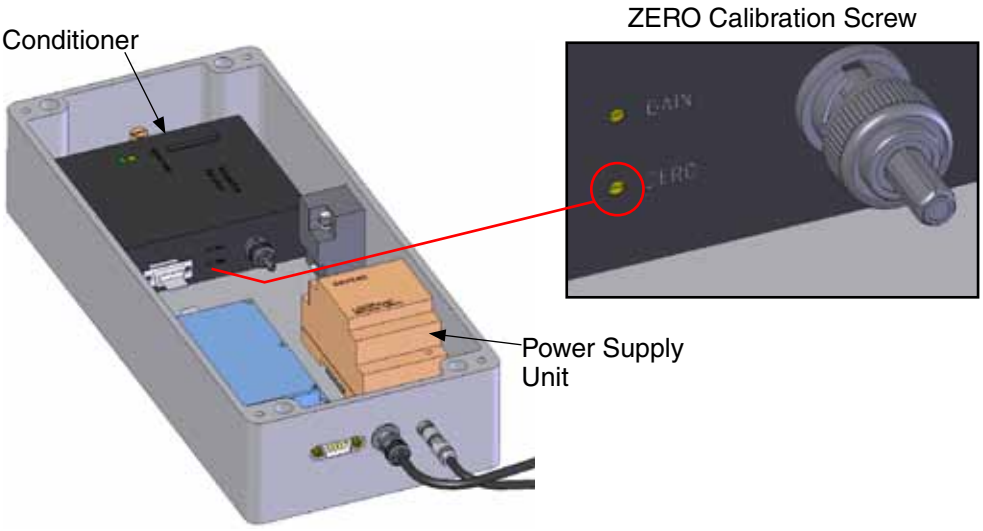


Figure 3–4 Zero Calibration 5 W Conditioner (TF 218 to TF 220 Sensors)



CAUTION: NEVER TOUCH THE "GAIN" ADJUSTMENT SCREW. IT IS ONLY USED AFTER A CONDITIONER REPLACEMENT OR REPAIR.

4. Measurement Considerations



CAUTION: WHEN PERFORMING STATIC MEASUREMENTS, IT IS POSSIBLE TO GO BEYOND NOMINAL TORQUE AND TOWARD THE TORQUE LIMIT WHICH CAUSES PLASTIC DEFORMATION. WHEN EXCEEDING THE NOMINAL TORQUE, ANY EXTRANEOUS LOADS SUCH AS AXIAL, SHEARING AND BENDING FORCES MUST BE AVOIDED.

4.1 DYNAMIC TORQUE

Static and dynamic measurements differ from one another by the evolution of torque over time. A constant torque produces static measurements, whereas varying torques can only be determined by dynamic measurement. TF Torque Flange Sensors have been designed to measure both static and dynamic torque.

4.2 DETERMINING THE NATURAL FREQUENCY OF A DRIVE TRAIN



CAUTION: CRITICAL ROTATIONAL SPEEDS AS WELL AS NATURAL FREQUENCIES HAVE TO BE TAKEN INTO CONSIDERATION IN ORDER TO AVOID RESONANCES AND POSSIBLE OVERLOADING OF THE TF TORQUE FLANGE SENSOR.

In order to determine the dynamic torque and frequency response, and to prevent any damage to the system, it is necessary to calculate the natural frequency of the drive train's torsional oscillations.

The drive train is considered a combination of torsion springs with intermediate flywheel masses. In the TF Sensor, the deformation area of the measuring flange is the weakest link in the rotating measuring chain and is subject to torsional vibrations. A good approximation of the dominant torsional resonant frequency is given in the following formula:

$$f_0 = \frac{1}{2\pi}\sqrt{C_t \frac{J_1 + J_2}{J_1 \cdot J_2}}$$

f_0	System natural frequency [Hz]
C_t	Torsional stiffness of the flange [N·m/rad]
J_1	Moment of inertia (driving element + mounting flange + ½ measuring flange) [kg·m²]
J_2	Moment of inertia (driven element + cardan shaft + ½ measuring flange) [kg·m²]

A more detailed analysis of the dynamic system response may require the study of publications on structural mechanics. However, the following simplified model of a drive train can often be used.

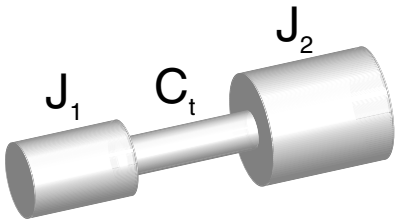


Figure 4–1 Simplified Physical Drive Train Model

Note: The natural torsional frequency of the drive train is lower due to the presence of the TF Torque Flange Sensor. The system's own natural frequency must then be recalculated to determine the influence of the TF Sensor.

The torsion spring describes the behavior of the measuring flange deformation zone. The torsional stiffness values (C_t) are indicated in the data sheet in *Section 1.2*. Both moments of inertia (J_1 and J_2) are generated by the two deformation areas and can be calculated by adding the moment of inertia of each individual element. The moment of inertia of the flange is also indicated in the data sheet. Consult with the suppliers of the couplings, driving element(s) and driven element(s) in order to obtain details on moment of inertia of the other drive train components.

The natural torsional frequency (f_0) determines the response of the torque measuring system and helps to determine whether rapid variations may influence the measuring system or whether the torque is amplified or damped by the drive train dynamics. The transfer curve is shown in *Figure 4–2* for various quality factor values (Q), depending on the torsional system damping factor. The graph charts the factor by which the torque will be amplified, depending on the frequency of the torsional oscillations.

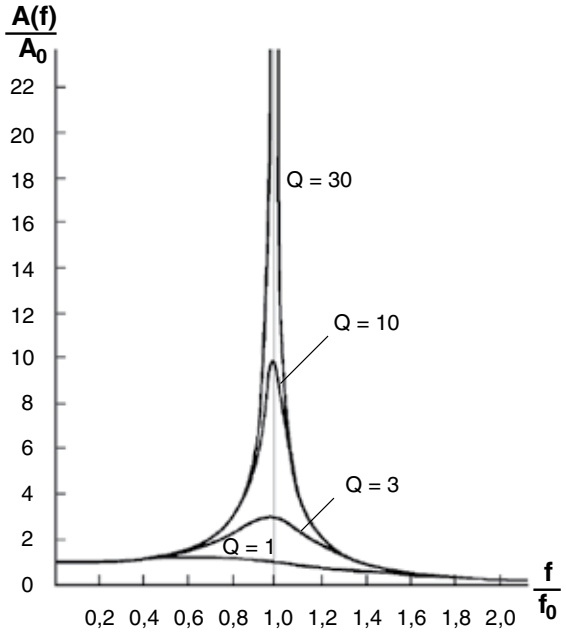


Figure 4–2 Drive Train Transfer Curve

Example:

Let us assume a natural frequency f_0 of 1000 Hz and a quality factor Q=10. A dynamic torque around 900 Hz (close to the natural frequency) would be read by the TF torque flange sensor and amplified by a factor of approximately 6. It is important to note that this amplification is not electrical but mechanical. The risk of overloading the TF Sensor is therefore real.

☞	Note:	In practice, the system will be configured and used so as never to get close to the natural frequency of the measuring chain. The Q value must, if possible, be "1". For this reason, the drive train torsional oscillation frequency must be below ~0.5 f_0.

4.3 MAXIMUM DYNAMIC AMPLITUDE

The dynamic peak-to-peak amplitude must not exceed 400% of the nominal torque of the TF Torque Flange Sensor. This is even true with alternating loads. This amplitude must remain within -200% $M_{nominal}$ and +200% $M_{nominal}$ as shown in the graph below.

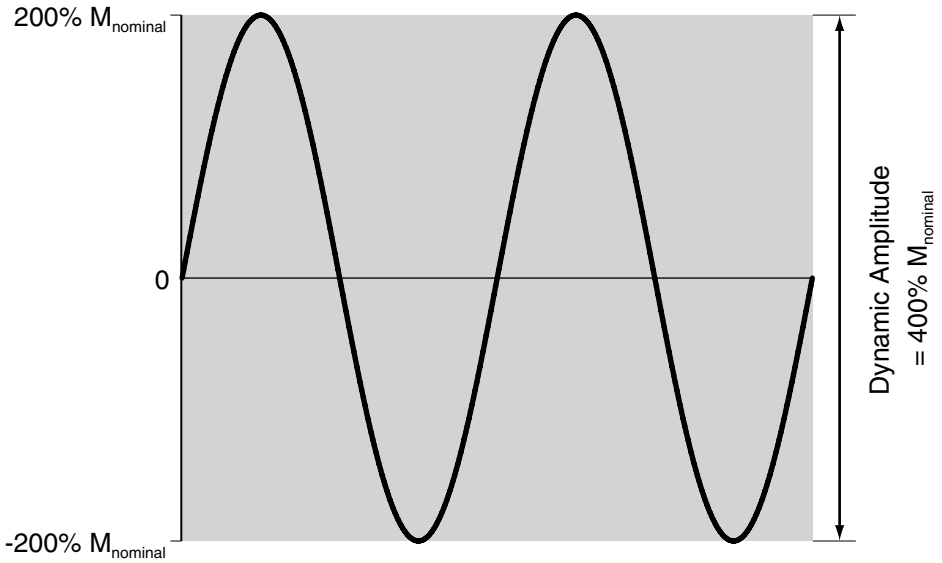


Figure 4–3 Admissible Dynamic Load

4.4 PARASITIC FORCES



CAUTION: NEVER EXCEED ADMISSIBLE LIMITS OF TORSIONAL MOMENTUM, AXIAL OR RADIAL FORCES. THE PARASITIC FORCES ARE TO BE AVOIDED AT MOST

If the TF Torque Flange Sensor is improperly installed, parasitic forces can act in both radial and axial directions on the sensor.

Radial forces generate torsional momentum on the TF Sensor which alters its center of gravity. The resulting imbalance will periodically load the TF sensor proportional to the rotational speed The influence of this load increases with rotational speed.

Axial or radial forces, misalignment or unbalance will distort the measuring precision of the sensor. Modulation of axial or radial forces under rotation may cause an anticipated fatigue of the sensor and shorten its life time.



Note: The values provided in the table are dynamic limits. The dynamic limit could be much lower depending on the speed of application, balancing quality, alignment and vibrations.

The following table lists the admissible forces and torque which can be applied to the TF Series Torque Flange Sensors without damage.

Model	Nominal Torque	Limit Torque	Rupture Torque	Bending Torque	Admissible Axial Force	Admissible Radial Force
	N·m	*N·m (150%–200% $M_{nominal}$)*	*N·m (400% $M_{nominal}$)*	*N·m*	*N*	*N*
TF 209	20	40	80	10	150	150
TF 210	50	100	200	25	375	375
TF 211	100	200	400	50	750	750
TF 212	200	400	800	100	1 500	1 500
TF 213	500	1 000	2 000	125	3 750	3 750
TF 214	1 000	2 000	4 000	300	7 500	7 500
TF 215	2 000	4 000	8 000	600	15 000	15 000
TF 216	5 000	10 000	20 000	1 500	37 500	37 500
TF 217	10 000	15 000	40 000	3 000	75 000	75 000
TF 218	20 000	40 000	80 000	6 000	140 000	140 000
TF 219	50 000	90 000	200 000	17 000	200 000	200 000
TF 220	100 000	200 000	400 000	35 000	400 000	400 000

4.5 TEMPERATURE COMPENSATION

TF Series Torque Flange Sensors are temperature-compensated in their operating range of 20° C and 85° C in a balanced-temperature environment where the temperature on each face of the measuring flange is the same. When mounted between a warm and a cold element, the TF Sensor displays variations of measuring accuracy. Mounting the TF Sensor in an environment with a thermal gradient between the flange faces must be avoided.

5. Operating Principles

5.1 TELEMETRY PRINCIPLE

Signal transmission between static and rotating components has always been plagued with technical problems. Magtrol's TF Series Torque Flange Sensors provide an interesting solution by using telemetry for signal transmission.

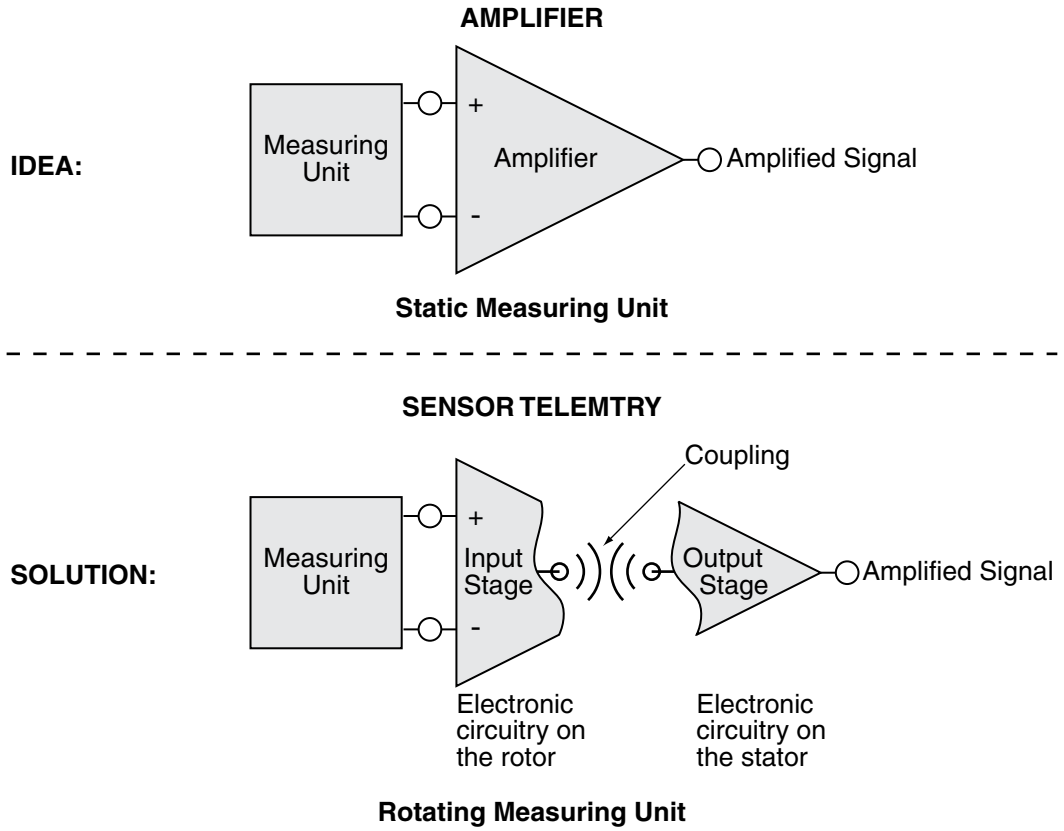


Figure 5–1 Telemetry Principle Applied to TF Torque Flange Sensors

5.2 SIGNAL TRANSMISSION

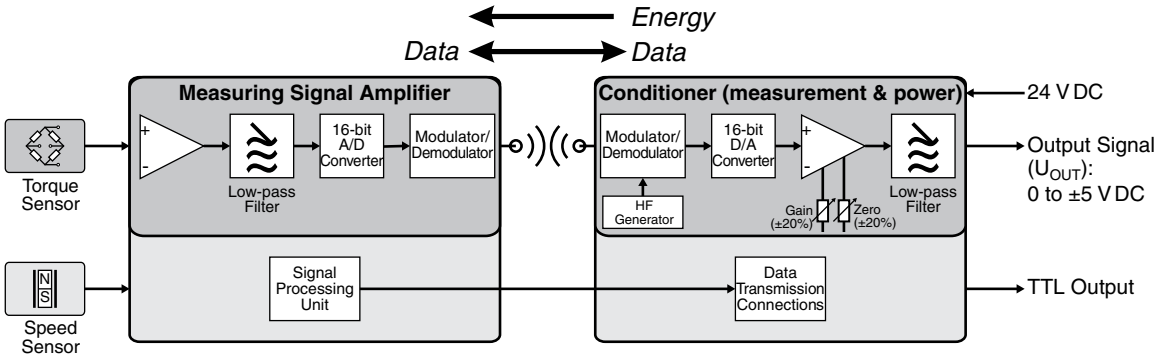


Figure 5–2 Signal Transmission Block Diagram

5.2.1 Measuring Flange to Conditioner

The torque signal is generated by strain gauges in a full-bridge configuration that are glued onto the inside of the measuring flange. This system has proven its efficiency and reliability over many decades with high measurement accuracy.

The signal delivered by the measuring flange is first amplified, and then sent to a low-pass filter before being digitalized with 16-bit resolution. Afterwards, the signal is modulated for transmission on an HF carrier wave (13.56 MHz). All this is carried out in the electronic module located inside the rotor. The measured signal is then transmitted by induction to the HF transmitter and finally demodulated by the conditioner.

5.2.2 Conditioner to Measuring Flange

A similar procedure is also used on the conditioner side which transmits the supply voltage (24 V) as well as the remote calibration signal to the rotor.

5.2.3 Speed Sensor to Speed Conditioner

Using the magnetoresistor principle, the (optional) speed sensor delivers a signal to the speed conditioner with a frequency proportional to the rotational speed.

6. Troubleshooting / Maintenance

6.1 DISMOUNTING THE MEASURING FLANGE

When dismounting the measuring flange from the drive train, make sure that all mounting screws are removed including those which are not visible from outside.

CAUTION: NEVER USE THE MEASURING FLANGE FOR LEVERAGE WHEN DISMOUNTING THE SENSOR.

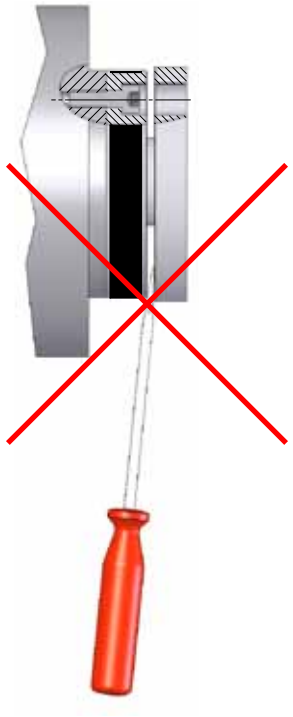


Figure 6–1 Improper Dismounting

6.2 LED INDICATORS

LED Color	If NOT illuminated	Recommendation
Yellow	Power supply problem.	Check conditioner power supply: TF 210 – TF 217: 24 V DC (stabilized) 350 mA min. TF 218 –TF 220: 220 V AC
	The conditioner is defect.	Return conditioner to Magtrol.
Red	HF transmitter power supply problem.	Check conditioner power supply, HF transmitter connectors and cable.
	HF transmitter is defect.	Return HF transmitter to Magtrol.
Green	Signal transmission problem.	Check HF transmitter (see *Section 2.3 – HF Transmitter Mounting*).
	Measuring flange is defect.	Return entire torque flange sensor (with its conditioner and HF transmitter) to Magtrol.

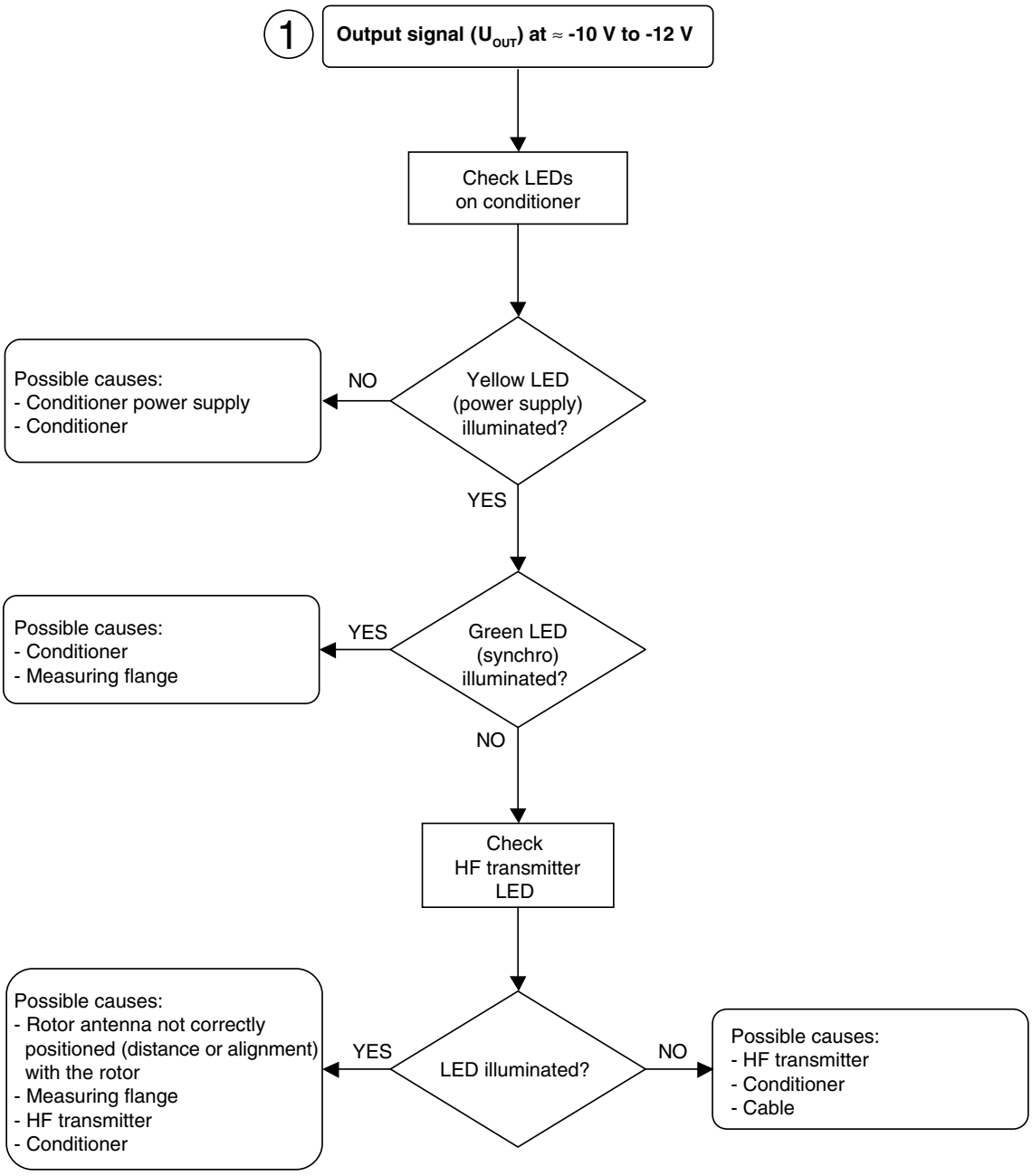
6.3 TROUBLESHOOTING

The following problems may occur with TF Series Torque Flange Sensors:

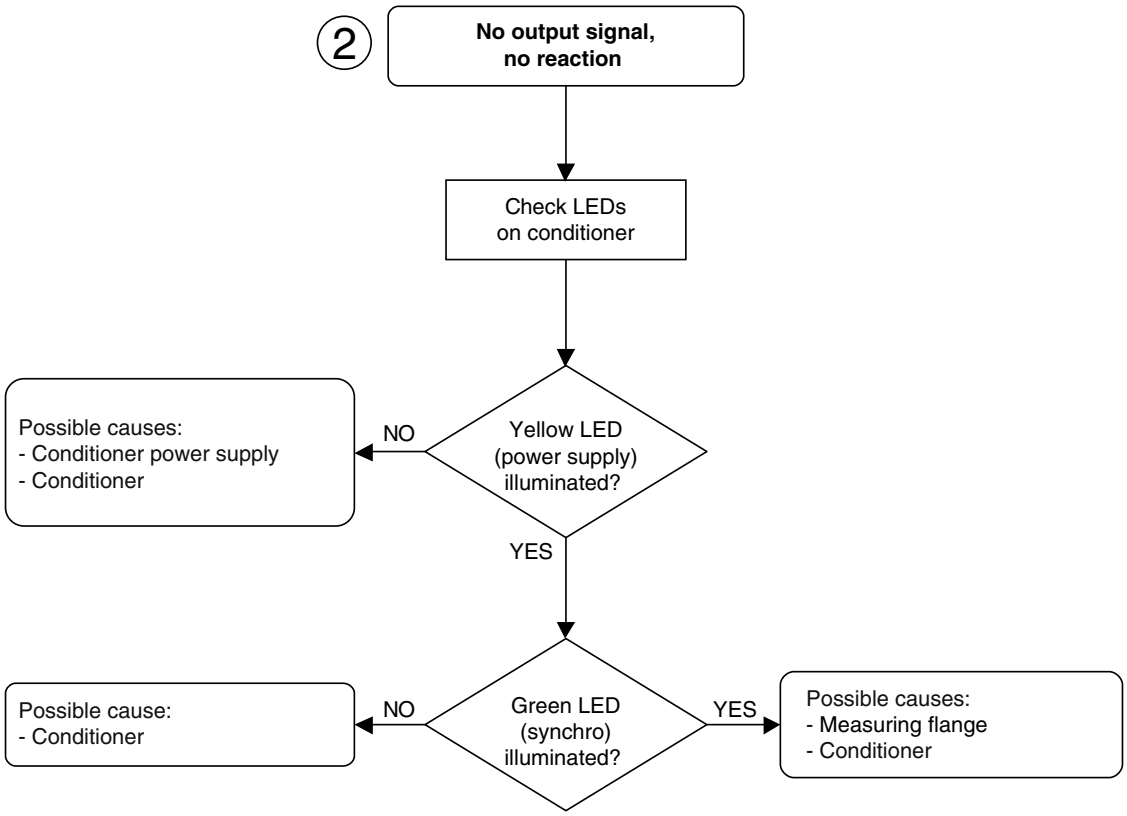
1. Output signal (U_{out}) remains between -10 V and -12 V
2. No output signal / no reaction
3. Signal is at ¾ of its nominal value (calibration value) when the measuring flange is unloaded, or the signal varies according to the load.
4. Unstable signal
5. "0" offset (signal behaves normally)

The possible causes of these problems are shown in the following flowcharts.

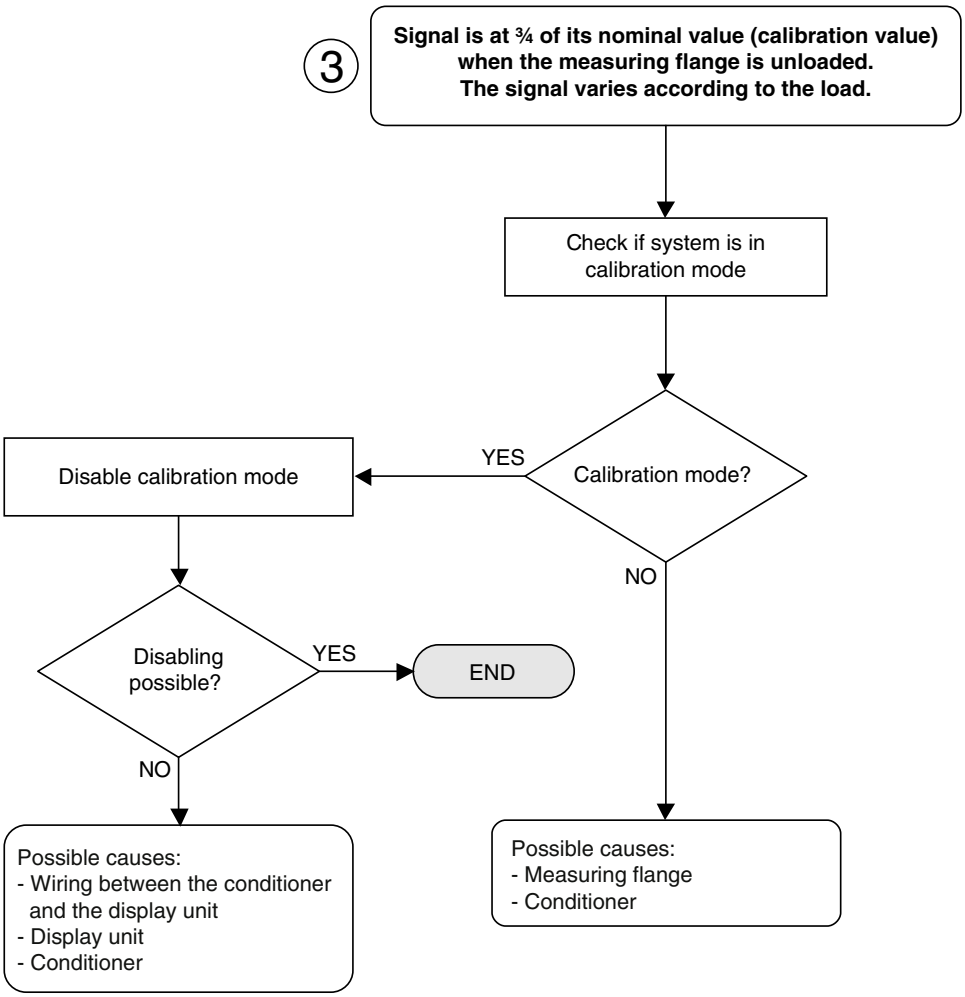
6.3.1 Output Signal Remains Between -10 V and -12 V



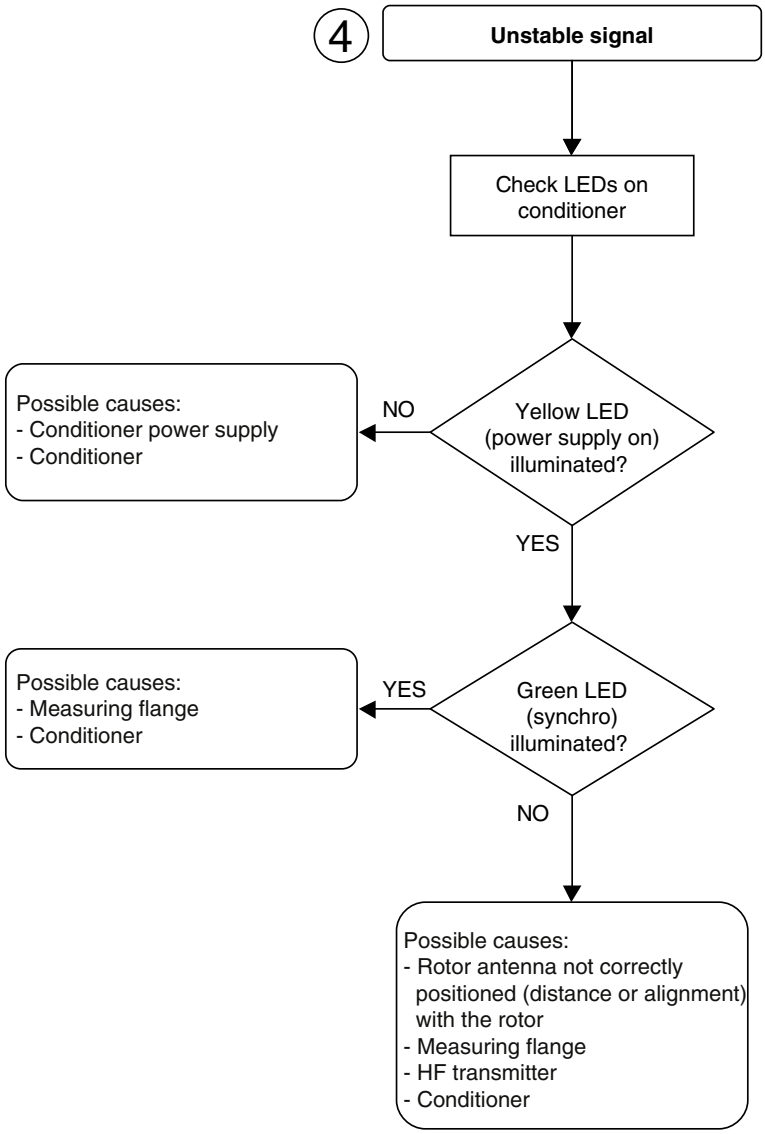
6.3.2 No Output Signal / No Reaction



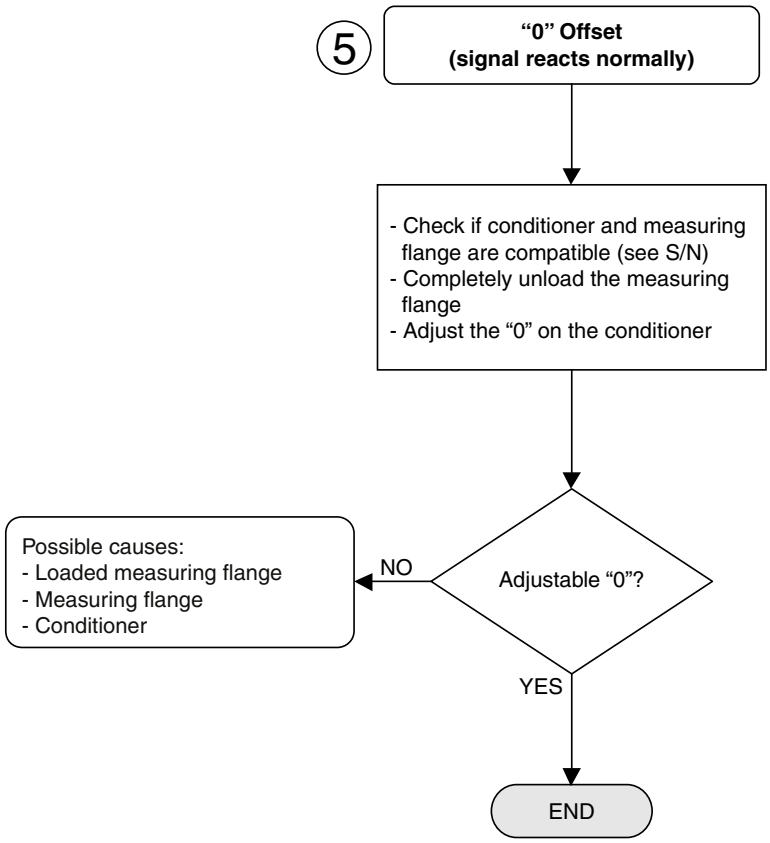
6.3.3 Signal at ¾ of its Nominal Value When Unloaded



6.3.4 UNSTABLE SIGNAL



6.3.5 "0" Offset with Normal Signal



Note: If you require additional assistance, please contact Magtrol Customer Service.

6.4 REPAIR

In case of a defect, please refer to both the *Warranty* and *Service Information* located in the back of this manual.



CAUTION: MAINTENANCE MUST BE PERFORMED BY MAGTROL IN ORDER TO GUARANTEE FUTURE MEASURING ACCURACY.

6.4.1 DEFECT REPORT

To allow Magtrol to complete the work in the best possible time, it is imperative that the following information be documented and included with your return shipment:

- Model number, part number (P/N), serial number (S/N), order number and date of purchase
- Description of the defect and the conditions in which it appeared
- Description of the test bench (drawing, photographs, sketches, etc.)
- Description of the tested object (drawing, photographs, sketches, etc.)
- Description of the test cycle

6.4.2 RETURNING TO MAGTROL

1. Carefully pack the complete TF Torque Flange Sensor kit (including HF transmitter, conditioner and cable).
2. Include the defect report, as described in *Section 6.4.1*.
3. Follow the procedure outlined in the back of this manual under *Service Information – Returning Equipment to Magtrol SA (Switzerland)*.

Magtrol Limited Warranty

Magtrol, Inc. warrants its products to be free from defects in material and workmanship under normal use and service for a period of twenty-four (24) months from the date of shipment. Software is warranted to operate in accordance with its programmed instructions on appropriate Magtrol instruments. This warranty extends only to the original purchaser and shall not apply to fuses, computer media, or any other product which, in Magtrol's sole opinion, has been subject to misuse, alteration, abuse or abnormal conditions of operation or shipping.

Magtrol's obligation under this warranty is limited to repair or replacement of a product which is returned to the factory within the warranty period and is determined, upon examination by Magtrol, to be defective. If Magtrol determines that the defect or malfunction has been caused by misuse, alteration, abuse or abnormal conditions of operation or shipping, Magtrol will repair the product and bill the purchaser for the reasonable cost of repair. If the product is not covered by this warranty, Magtrol will, if requested by purchaser, submit an estimate of the repair costs before work is started.

To obtain repair service under this warranty, purchaser must forward the product (transportation prepaid) and a description of the malfunction to the factory. The instrument shall be repaired at the factory and returned to purchaser, transportation prepaid. **MAGTROL ASSUMES NO RISK FOR IN-TRANSIT DAMAGE.**

THE FOREGOING WARRANTY IS PURCHASER'S SOLE AND EXCLUSIVE REMEDY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, OR FITNESS FOR ANY PARTICULAR PURPOSE OR USE. MAGTROL SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OR LOSS WHETHER IN CONTRACT, TORT, OR OTHERWISE.

CLAIMS

Immediately upon arrival, purchaser shall check the packing container against the enclosed packing list and shall, within thirty (30) days of arrival, give Magtrol notice of shortages or any nonconformity with the terms of the order. If purchaser fails to give notice, the delivery shall be deemed to conform with the terms of the order.

The purchaser assumes all risk of loss or damage to products upon delivery by Magtrol to the carrier. If a product is damaged in transit, PURCHASER MUST FILE ALL CLAIMS FOR DAMAGE WITH THE CARRIER to obtain compensation. Upon request by purchaser, Magtrol will submit an estimate of the cost to repair shipment damage.

Service Information

RETURNING MAGTROL EQUIPMENT FOR REPAIR AND/OR CALIBRATION

Before returning equipment to Magtrol for repair and/or calibration, please visit Magtrol's Web site at http://www.magtrol.com/support/rma.htm to begin the Return Material Authorization (RMA) process. Depending on where the equipment is located and which unit(s) will be returned, you will be directed to either ship your equipment back to Magtrol, Inc. in the United States or Magtrol SA in Switzerland.

Returning Equipment to Magtrol, Inc. (United States)

When returning equipment to Magtrol, Inc.'s factory in the United States for repair and/or calibration, a completed Return Material Authorization (RMA) form is required.

1. Visit Magtrol's Web site at http://www.magtrol.com/support/rma.htm to begin the RMA process.
2. Complete the RMA form online and submit.
3. An RMA number will be issued to you via e-mail. Include this number on all return documentation.
4. Ship your equipment to:
   MAGTROL, INC.
   70 Gardenville Parkway
   Buffalo, NY 14224
   Attn: Repair Department
5. After Magtrol's Repair Department receives and analyzes your equipment, a quotation listing all the necessary parts and labor costs, if any, will be faxed or e-mailed to you.
6. After receiving your repair estimate, provide Magtrol with a P.O. number as soon as possible. A purchase order confirming the cost quoted is required before your equipment can be returned.

Returning Equipment to Magtrol SA (Switzerland)

If you are directed to ship your equipment to Switzerland, no RMA form/number is required. Just send your equipment directly to Magtrol SA in Switzerland and follow these shipment instructions:

1. Ship your equipment to:
   MAGTROL SA
   After Sales Service
   Route de Montena 77
   1728 Rossens / Fribourg
   Switzerland
   VAT No: 485 572
2. Please use our forwarder : TNT • 1-800-558-5555 • Account No 154033
   Only ship ECONOMIC way (3 days max. within Europe)
3. Include the following documents with your equipment:
   - Delivery note with Magtrol SA's address (as listed above)
   - Three pro forma invoices with:
     - Your VAT number
     - Description of returned goods
     - Noticed failures
     - Value - for customs purposes only
     - Origin of the goods (in general, Switzerland)
4. A cost estimate for repair will be sent to you as soon as the goods have been analyzed. If the repair charges do not exceed 25% the price of a new unit, the repair or calibration will be completed without requiring prior customer authorization.

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Subsidiaries in:
Germany • France
China • India

Worldwide Network
of Sales Agents

ISO 9001
BUREAU VERITAS
Certification